JUL

IN TWO SECTIONS—SECTION ONE

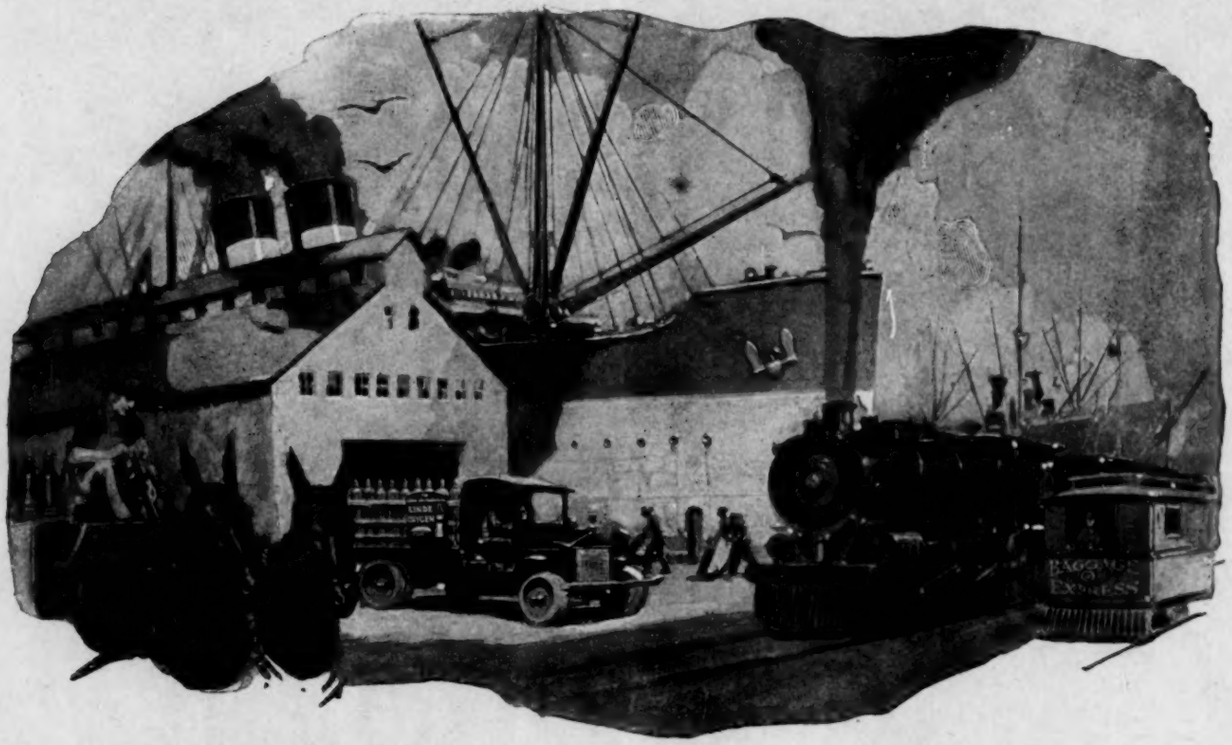
MECHANICAL ENGINEERING

THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ACCOUNT OF ST. LOUIS MEETING
APPEARS IN THIS ISSUE

JULY 1920

PUBLISHED MONTHLY BY THE SOCIETY
29 WEST 39TH STREET, NEW YORK, U.S.A.



That You May Be Served Promptly

LINDE Oxygen must reach Linde customers *on time*, Neither tie-ups nor storms, floods nor fires shall interrupt Linde Service and to that end every means of transportation is called into use.

When the regular channels of commerce are closed, when man or nature keep the wheels from turning—Linde finds a way. By trolley, motor, mule-train or sled through ice-jammed waters, or over burning sands—Linde must live up to its promises—must *deliver* wherever it is humanly possible.

Because of this super-service, oxygen users throughout America depend upon Linde delivery with as much confidence as they depend upon the uniform purity of Linde Oxygen.

That is why Linde must produce more oxygen than any other maker in the world.

THE LINDE AIR PRODUCTS CO.

30 EAST 42ND ST., N. Y. KOHL BLDG., SAN FRANCISCO

THE LARGEST PRODUCERS OF OXYGEN IN THE WORLD

L515

Mechanical Engineering

The Journal of The American Society of Mechanical Engineers

VOLUME 42 JULY, 1920 NUMBER 7

TABLE OF CONTENTS

An Experimental Investigation of Steel Belting, F. G. Hampton, C. F. Leh and W. E. Helmick 369
Design of Ore Fleet for Upper Mississippi, W. S. Mitchell 379
Superchargers for Airplane Engines, S. A. Moss 383
Spring Meeting of The American Society of Mechanical Engineers 386
Motor Gasoline from Heavier Hydrocarbons, F. W. Padgett 400
Engineering Survey (Review of Periodicals) 403
Engineering Research 414
Cleveland Engineers Hold Joint Meeting 416
Work of the Boiler Code Committee 417
Correspondence 419
Editorial Notes 420

Federated American Engineering Societies—Plain Limit Gages for General Engineering Work—Swiss Mission to Study American Economic Conditions—Austrian Engineers Appeal for Help—The Robert W. Hunt Medal Fund—Slow Delivery of Mechanical Engineering Bulletin.

Organizing Conference Plans Federation of Engineering Societies 422
Industrial Relations Association of America 424
Edmund Gybbon Spilsbury 426
The Engineering Index 1*a*
A. S. M. E. Affairs (Section Two) 97–108
ADVERTISING SECTION:
Display Advertisements 2*b*
Consulting Engineers 118
Classified List of Mechanical Equipment 122
Classified Advertisements 137
Alphabetical List of Advertisers 140

PUBLISHED MONTHLY BY

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

29 West Thirty-Ninth Street, New York

PRICE 40 CENTS A COPY, $4.00 A YEAR; TO MEMBERS AND AFFILIATES, 30 CENTS A COPY, $3.00 A YEAR. POSTAGE TO CANADA, 50 CENTS ADDITIONAL; TO FOREIGN COUNTRIES, $1.00 ADDITIONAL

C. 55. The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions.

Entered as second-class matter, January 4, 1912, at the Post Office, New York, N. Y., under the act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on July 8, 1918.

MECHANICAL ENGINEERING

A Journal Unique in its Field — A Journal which Surveys the Field and Reviews for its Readers the World's Technical Periodicals — The Record of a Year.

IN the annual volume of The Engineering Index, just issued by The American Society of Mechanical Engineers, there are over 12,000 items referring to articles in 603 periodicals, comprising the best of the world's technical press in all branches of engineering—civil, mining, mechanical, electrical, etc.

It is significant that of these 603 periodicals 200, or 33 1-3 per cent, treat of the various branches of *mechanical engineering* and the intimately related subject, industrial management. The next largest number devoted to any one branch is in the field of electrical engineering where there are 74 periodicals. There are also 62 general publications, mostly foreign, which contain mechanical engineering articles.

So broad is the field of the mechanical engineer, and so diversified are his interests, that his journals have multiplied and specialized, divided and sub-divided, to a far greater extent than those which cover any other branch of engineering.

The position of MECHANICAL ENGINEERING, the Journal of the A. S. M. E., among this great group of papers, is that of a general publication which not only covers the activities of the Society, but serves as a directory to the multitude of class journals and other technical literature, most of which no engineer has the time nor opportunity to review.

Every engineer needs first of all the class journals in his own special field. Beyond this he needs to know what is being accomplished by other engineers in other fields, and it is the function of MECHANICAL ENGINEERING to supply him with this information.

Now that the Society's meetings for the past season have come to a close and preparations are under way for the fall activities, it will be of interest to review what MECHANICAL ENGINEERING has accomplished during the past year and indicate the extent to which it has fulfilled its objects.

In what follows will be found a selected list of titles of articles which have appeared, grouped under several headings. In addition to these groups of articles The Engineering Index, to which reference has already been made, has been a valued feature for 18 months.

Leading Articles in Mechanical Engineering for the Current 12 Months

Aeronautics. Aeronautic Instruments, Mayo D. Hersey, May, 1920.

Air Fans for Driving Generators on Airplanes, Capt. G. Francis Gray, Lt. John W. Reed and P. N. Elderkin, June, 1919.

Future of Aviation, Col. E. A. Deeds, Jan., 1920.

Physical Basis of Air-Propeller Design, F. W. Caldwell and E. N. Fales, April, 1920.

Rectilinear Flight of Aeroplanes, A. Rateau, May, 1920.

Industrial and Economic. Appraisal and Valuation Methods, David H. Ray, Dec., 1919.

Causes of Industrial Unrest and the Remedy, Frederick P. Fish, Jan., 1920.

Industrial Housing—A Financial Problem, Leslie H. Allen, June, 1920.

Industrial Personnel Relations, Arthur H. Young, July, 1919.

Status of Industrial Relations, L. P. Alford, June, 1919.

Systems for Mutual Control of Industry, William L. Leiserson, Jan., 1920.

Wage Payment, A. L. DeLeeuw, Dec., 1919.

What May We Expect of Profit Sharing in Industry? Ralph E. Heilman, Jan., 1920.

Machine Construction. Certification of Gages at Bureau of Standards, H. L. Van Keuren, Oct., 1919.

Production of Liberty Motor Parts at Ford Plant, W. F. Verner, June, 1919.

Tight-Fitting Threads for Bolts and Nuts, Chester B. Lord, April, 1920.

Machine Design. Centrifugal Compressors, Gustav Fluegel, Oct., 1919.

A Dredging Pump of Novel Construction, W. J. White, Jan., 1920.

Mechanical Lifts—Past and Present, Lieut. J. F. Robbins, June, 1919.

New Type of Hydraulic-Turbine Runner, Forrest Nagler, Dec., 1919.

Perfected High-Pressure Rotary Compressor, Chester B. Lord, Nov., 1919.

Slow-Speed Tests of Kingsbury Thrust Bearings, H. A. S. Howarth, Dec., 1919.

Turbo-Compressor Calculations, Allen H. Blaisdell, March, 1920.

Military. Army Motor-Transport Vehicles, John Younger, Nov., 1919.

First Transcontinental Motor Convoy, Lieut. E. R. Jackson, March, 1920.

German Defenses on the Coast of Belgium, Lt.-Col. H. W. Miller, June, 1920.

German Long-Range Gun, Lt.-Col. H. W. Miller, Feb., 1920.

Refrigeration Requirements of Chemical Warfare, Major A. M. Heritage, Oct., 1919.

Power and Combustion. Central-Station Heating in Detroit, J. H. Walker, June, 1919.

Economy of Arizona Power Plants Using Oil Fuel, C. R. Weymouth, June, 1919.

Power and Combustion (Continued).

Emergency Fleet Corporation Water-Tube Boiler for Wood Ships, F. W. Dean and Henry Kreisinger, Dec., 1919.

Locomotive Feedwater Heating, Thomas C. McBride, May, 1920.

Pulverized Coal as a Fuel, N. C. Harrison, Aug., 1919.

Pulverized Coal as a Fuel for Boilers, Edward R. Welles and W. H. Jacobi, Sept., 1919.

Pulverized Coal for Stationary Boilers, Fred'k A. Scheffler and H. G. Barnhurst, Aug., 1919.

Pulverized Coal in Metallurgical Furnaces at High Altitudes, Otis L. McIntyre, April, 1920.

Scientific Development of the Steam Locomotive, John E. Muhlfeld, Nov., 1919.

Separation of Dissolved Gases from Water, J. R. McDermet, May, 1920.

Stoker for Burning Eastern Coals, L. R. Stowe, May, 1920.

Research. Condition of Research in the United States, Arthur M. Greene, Jr., July, 1919.

Industrial Research Laboratory Organization, K. C. Mees, Aug., 1919.

Organization of an Industrial Laboratory, A. D. Little and H. E. Howe, Aug., 1919.

Research Work on Malleable Iron, Enrique Touceda, July, 1919.

Scientific. Dissipation of Heat by Various Surfaces, T. S. Taylor, April, 1920.

Flow of Air Through Small Brass Tubes, T. S. Taylor, June, 1920.

Flow of Water Through Condenser Tubes, William L. De Baufre and Milton C. Stuart, Dec., 1919.

Improved Weir for Gaging in Open Channels, Clemens Herschel, Feb., 1920.

Simplification of Venturi-Meter Calculations, Glenn B. Warren, April, 1920.

Miscellaneous. Fire Engines and Effective Fire Fighting, Charles H. Fox, June, 1919.

Reliability of Materials and Mechanism of Fractures, C. de Freminville, Paris, France, April, 1920.

River Transportation in the Mississippi Valley, E. W. Schadek, May, 1920.

Section Papers Published During the Past Year

Aeronautics. The Horsepower of Resistance in Aeroplane Design, N. L. Lieberman, Sept., 1919. (Buffalo).

Inspection of Airplanes at Romorantin, France. Lieut. Earl E. Ives, Oct., 1919. (Mid-Continent).

Army. The Right Man in the Right Place in the Army, Lt.-Col. John J. Swan, May, 1919. (New York).

Fuels and Power. Fuel Saving in Industrial Plants, John F. Tinsley, Sept., 1919., (Worcester).

The Large Steam Turbine, J. F. Johnson, April, 1919, (Philadelphia).

The Proper Balancing of Fuel, Lubricant and Motor, Wm. F. Parish, March, 1920, (Chicago).

The Tank Car Maintenance Problem, Paul Bateman, Oct., 1919, (Mid-Continent).

Industrial and Economic. The Human Factor in the Operation of Industry, Dr. Henry R. Seager, Nov., 1919, (New York).

Industrial Development in the Trans-Missouri Region, P. F. Walker, Oct., 1919, (Mid-Continent).

Research and Social Evolution, C. F. Hirshfeld, Feb., 1920, (Indianapolis Meeting—Mid-West Sections).

Some Twentieth-Century Problems, William B. Dickson, May, 1919, (Philadelphia).

Machine Shop. Certification of Gages at Bureau of Standards, H. L. Van Keuren, Oct., 1919, (Washington, D. C.).

Electric Arc Welding, F. A. Anderson, May, 1919, (San Francisco).

Gage Limits in Interchangeable Manufacture, E. C. Peck, Oct., 1919, (Washington, D. C.).

Navy. Torpedo-Boat Destroyers in the Making, Commander James Reed, Sept., 1919. (San Francisco).

Research. The Testing of Farm Tractors, Charles H. Benjamin, Feb., 1920, (Indianapolis Meeting—Mid-West Sections).

A Volumetric Efficiency Test of a Vacuum Pump, George S. Tayman, Oct., 1919, (Mid-Continent).

A Selection of Titles of Articles Which Have Appeared on Public Affairs and Society Interests

Division of Engineering of National Research Council
International Standardization
Enemy Opinion of the Liberty Motor
Report of the A.S.M.E. Committee on Industrial Relations
The Training of Industrial Executives
After-War European Industrial Activtiy
Formulation of Power Test Codes
Recataloging the U. E. S. Library
Life of Andrew Carnegie
The James Watt Centenary
Salaries of Engineers in Canada.
Engineers Honor Eugene Schneider of France
Pan-American Financial Congress
International Electrotechnical Commission
Civil Engineers Discuss Development Problems
First Step Toward Federation of Engineering Societies
Charles Warren Hunt Appointed Secretary Emeritus of the American Society of Civil Engineers
Employees' Representation in Management of Industry
Engineering Foundation Reports Progress in Research
Classification and Compensation of Engineers
National Public Works Department Association Holds Conference in Washington
Autogenous Welding of Boilers and Pressure Vessels
Engineers Honor Memory of John Eriesson
Charles de Freminville Elected to Honorary Membership in the A.S.M.E.
A University for the Industries as Well as for the People
Diesel-Electric Drive for Ships
Recent Developments in American Aeronautics
Major Schroeder's Record Altitude Flight
History of the Students' Army Training Corps
Engineering Organization in India
Proposed National Labor Program
American Engineering Standards Committee Organizing Standardization Work
Herbert C. Hoover Addresses Mining Engineers
The Engineer's Salary and Present Conditions
Government Activities in Engineering. Alaskan Railroad
Classification of Subordinate Railroad Engineers
Congress Passes General Land Leasing Bill
Congress to Study Reorganization of Federal Executive Departments
Engineer Corps Under the Proposed Army Reorganization
Engineering Council Joins Chamber of Commerce
Engineering Legislation in Congress
Government Aid in Road Building
Important Flood Legislation
Licensing of Engineers
Mail Tunnel Systems for Large Cities
New Board of Surveys and Maps
Patent Legislation
Reclamation Service
Reclassification and Compensation in the Government Service
Road Legislation
Technical Work at Bureau of Standards
War Department Equipment for Trade, Technical Schools and Universities
Water Power Bill Passes Senate
Meetings of Other Societies. American Institute of Electrical Engineers
National Machine Tool Builders' Association
Society of Heating and Ventilating Engineers
National Electric Light Association
Engineering Society of Western Massachusetts
American Society of Civil Engineers
American Society for Testing Materials
American Institute of Mining and Metallurgical Engineers
Society of Automotive Engineers
National Department of Public Works Association
Engineering Institute of Canada
Western Society of Engineers
and many others. A total of 70 reports of meetings of other Societies have been published during the past 12 months.

Important Engineering Survey Articles of the Past Year

Aeronautics. Investigation of Muffling Problem for Aeroplanes, G. B. Upton and V. R. Gage (*Natl. Advis. Comm. Aeronautics*), April, 1920.

Maintaining Constant Pressure Before Carburetors of Aero Engines Regardless of Their Altitude, L. V. Spencer (*Aerial Age Weekly*), July, 1919.

Napier Lion Aircraft Engine (*Automobile Engr.*), Oct., 1919.

Tarrant Triplane (*The Engineer*), July, 1919.

Engineering Materials. Corrosion of Condenser Tubes (*The Engineer*), May, 1920.

Effect of Corrosion on Wrought Manganese Bronze under Tensile Stress, P. D. Merica and R. W. Woodward (*American Machinist*), Sept., 1919.

Fatigue of Metals under Repeated Stress, H. F. Moore (*Jl. Western Soc. Engrs.*), March, 1920.

Strength and Other Properties of Wire Rope, J. H. Griffith and J. G. Bragg (*Technologic Paper no.* 121, *Bur. Standards*), July, 1919.

Fuels and Firing. Alcohol Fuel Committee's Report (*Motor Traction*), Aug., 1919.

Low-Temperature Distillation of Coal, C. M. Garland (*Power*), Oct., 1919

Low-Temperature Distillation of Sub-Bituminous Coal, H. K. Benson and R. E. Canfield (*Jour. Ind. and Eng. Chem.*), June, 1920.

Gas Turbines. Develop. of Holzwarth Gas Turbine Since 1914, Hans Holzwarth (*Zt. Ver. deut. Ingenieure*), April, 1920.

Hoisting Machinery. Shipyard Crane, W. H. Hok (*Marine Engrg. and Can. Merchant Service Guild Review*), May, 1920.

Hydraulic Engineering. Comprehensive Plotting of Water Turbine Characteristics, K. R. Kennison (*Proc. Am. Soc. Civil Engineers*), Oct., 1919.

Determination Velocity of Flow of Liquids, C. Camichel (*Revue Générale de l'Electricite*), Jan., 1920.

Hexagonal Chart for Finding Velocity of Water in Pipes, C. W. Anthony (*Engineering News-Record*), Sept., 1919.

Italian Water Turbines, N. Davey (*The Engineer*), Jan., 1920.

Orifice as Means of Measuring Flow of Water Through a Pipe, R. E. Davis and H. H. Jordan (*Univ. Ill. Bull.*), Dec., 1919.

Seewer Governor for High-Head Hydraulic Turbines of Pelton Type, A. Strickler (*Bull. Technique de la Suisse Romande*), Nov., 1919.

Surge Pressures in Pipe Lines, R. Bennett (*Engineering News-Record*), July, 1919.

Hydraulic Machinery. Balanced Hydraulic Valve (*Engineering*), April, 1920.

Determination of Energy Losses in Centrifugal Machinery on Basis of Their Characteristic Curves, R. Muller (*Zt. des Ver. deut. Ingenieure*), Dec., 1920.

Internal-Combustion Engineering. Practical Brake-Horsepower Formula for Internal-Combustion Engines, H. Lemp (*Gen. Elec. Review*), May, 1920.

Valve Failures and Valve Steels of Internal Combustion Engines, L. Aichison (*Automobile Engr.*), Jan., 1920.

Fuels for Aircraft Engines (*Natl. Advis. Comm. Aeronautics*), March, 1920.

Liberty Motor, O. Schwager (*Der Motorwagen*), Aug., 1919.

Tosi Diesel Engines for Submarines (*Engineering*), Aug., 1919.

Doxford Oil Engine (*The Engineer*), Sept., 1919.

Effect of Neutral Gases on Temperature of Working Fluid in an Internal-Combustion Engine, K. Takemura (*Jl. Soc. of Mechanical Engrs., Tokyo*), Sept., 1919.

Investigation of Airplane Fuels, E. W. Dean and C. Netzen (*Jl. Soc. of Automotive Engrs.*), Sept., 1919.

Sanders Pressure Turbine (*Jl. Soc. Automotive Engrs.*), Nov., 1919.

Lubricants. Oiliness of Lubricants (*Engineering*), Feb., 1920.

Theory of Practice of Lubrication: The "Germ" Process (*Jour. Soc. Chem. Industry*), May, 1920.

Machine Elements. Ball and Roller Bearings, Capt. J. B. Swan (*Automobile Engineer*), Sept., 1919.

High Speed Turbine Gears, G. Stoney (*Engineering*), Jan., 1920.

Mechanical Reduction Gears in Warships, Engr.-Comm. Tostevin (*Engineering*), May, 1920.

Machine Shop. Cutting Power of Lathe Turning Tools, Geo. W. Burley (*Jl. Instn. Mech. Engrs.*), Feb., 1920.

Pots and Boxes Used for Carbonizing, H. H. Harris (*Iron Age*), April, 1920.

Tolerances in Mechanical Construction (*Le Genie Civil*), July, 1919.

Machine Tools. Crankshaft Lathe, E. Viall (*American Machinist*), Oct., 1919.

Foote-Burt "Way" Drilling Machines, J. V. Hunter (*American Machinist*), June, 1920.

Relieving Attachment for Lathes (*Engineering*), April, 1920.

Management. Fatigue and Its Effect on Production, A. Vautrain (*Tecknik und Wirtshaft*), June, 1920.

Marine Engineering. British Battle Cruiser "Hood" (*Engineering*), May, 1920.

Turbine Gear Drive for Torpedo-Boat Destroyers, W. B. Flanders (*Electric Jl.*), May, 1920.

Mechanics. Influence of Various Factors on Rise of Longitudinal Internal Stresses Due to Rapid Cooling of Steel Cylinders, M. Portevin (*Comptes Rendus hebd. des Seances de l'Académie des Sciences*), Feb., 1920.

Stability of Long Struts of Variable Section, Prof. A. Ono (*Memoirs Coll. of Engineering, Kyushu Imperial Univ.*), Feb., 1920.

Metallurgy. Occlusion of Gases by Metals (*Trans. Faraday Soc.*), Dec., 1919.

Motor-Car Engineering. Producer Gas for Motor Vehicles, D. J. Smith, March, 1920.

Physics. Arrangement of Electrons in Atoms and Molecules, I. Langmuir (*General Elec. Review*), Sept., 1919.

Power Plants. Calculation of Dimensions and Conditions of Operation of Surface Condensers with Air Leakage, K. Hoefer (*Zt. des Ver. deut. Ingenieure*), Dec., 1919.

Pneumatic Steam Turbine Governor (*Power*), Oct., 1919.

Present Limits of Speed and Power of Single Shaft Steam Turbines and Turbo-Generators (*Proc. Am. Inst. Elec. Engrs.*), Jan., 1920.

Power Transmission. Standardization of Power Plants, L. R. Lee (*Power*), April, 1920.

Power Transmission by Sonic Waves, J. Herck (*Bull. Technique du Bur. Veritas*), May, 1920.

Pumps. Water Pumps of the Drainage Station at Codigoro (*Schweizerische Bauzeitung*), Oct., 1919.

Railroad Engineering. Last Stand of Reciprocating Engine, A. H. Armstrong (*Jl. Am. Inst. Elec. Engrs.*), June, 1920.

Wind Resistance on a Train, C. F. Dendy Marshall (*Railway Mechanic Eng.*), Aug., 1919.

Refrigeration. Design of CO_2 Machines, John E. Starr (*Refrig. World*), Sept., 1919.

Salt Precipitation by Refrigeration, B. Block (*Zt. f. d. gesamte Kalte-Industrie*), Feb., 1920.

Scientific Problems of Cold-Storage Industries, W. B. Hardy (*Cold Storage and Ice Assoc.*), May, 1920.

Test of a 2-ton Clothel Refrigerating Machine, M. C. Stuart (*Jl. Am. Soc. Naval Engrs.*), Nov., 1919.

Quincy Market Cold Storage Plant at Boston, Chas. H. Bromley (*Power*), Jan., 1920.

Safety Engineering. Spontaneous Combustion, W. Smith (*Jl. Royal Soc. Arts*), Aug., 1919.

Steam Engineering. Bucket Efficiency of Impulse and Reaction Steam Turbines, Prof. Tore G. E. Lindmark (*Teknisk Tidzkrift Mekanik*), July, 1919.

Determination of Efficiency of Turbo-Alternator, S. F. Barclay and S. P. Smith (*Jl. Instn. Elec. Engrs.*), Aug., 1919.

Employment of Nozzles Instead of Cylinders or Wheels in Turbines, Prof. R. Mollier (*Zt. Ver. deut. Ing.*), Feb., 1920.

Testing and Measuring. Method of Reaching Extreme Altitudes, R. H. Goddard (*Smithsonian Misc. Collections*), March, 1920.

Thermodynamics. New Thermodynamic Cycle, Wm. J. Walker (*Engineering*), May, 1920.

Theory of Equilibrium Conditions in Saturated Steam, H. H. Martin (*Engineering*), Dec., 1919.

MECHANICAL ENGINEERING

THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 42 July 1920 Number 7

An Experimental Investigation of Steel Belting

Particulars Regarding Belt Material and the Joints Used—Description of Apparatus Employed in Tests—Determination of Relationships Existing Between Horsepower Transmitted, Velocity of Slip on Pulleys, and Coefficient of Friction

By F. G. HAMPTON, C. F. LEH, AND W. E. HELMICK, STANFORD UNIVERSITY, CAL.

At the Annual Meeting of The American Society of Mechanical Engineers, held December 2 to 5, 1919, in New York, Student and Junior prizes were awarded to the authors of the following paper. It treats of an investigation undertaken by them at Leland Stanford University as a partial requirement for the degree of engineer. Part I was written by Messrs. Hampton and Leh in 1918, and Part II by W. E. Helmick the year following. The first section deals with a description of the apparatus employed, the character of the belting, and a discussion of the results obtained in investigating the coefficients of friction and velocity of slip. Part II deals more particularly with the slip of the belting, which the original investigators recognized should be more carefully studied.

PART I GENERAL INVESTIGATIONS

ATTENTION has been called from time to time to the successful use of thin ribbons of steel for belting, and the purpose of the experimental work herein described was to determine as far as time would permit the characteristics of operation and the general laws controlling the performance of this means of power transmission. The literature on the subject of steel belts is very limited, and so far as is known there has been little or no experimental work done.

The controlling features of the design of an apparatus for testing steel belting may be enumerated as follows:

1 The machine must be so constructed that very high speeds may be obtained, and also means provided to vary the speed over as large a range as possible
2 Since very high efficiencies are expected, it is necessary to provide means for measuring, as accurately as possible, the losses of power which occur in the belt
3 The apparatus must be so constructed that the tensions in the tight and loose side may be accurately determined
4 On account of the relatively small slip it is necessary to provide specially constructed apparatus to accurately determine this variable
5 For the sake of convenience it is necessary to have the machine built so that belts can be changed easily and different lengths used.

Description of Apparatus

Two special high-speed pulleys were constructed upon which the belt to be tested was run. Since the speed at which cast iron can be safely run is far below that which was desired, it was necessary to select a stronger material and so construct the pulleys that they could be faced with some other material than steel.

The pulleys used were built in the department shops by the authors and consisted of two boiler-plate disks, a cast-iron hub, and a wooden rim. The pulleys were made relatively large in order that high peripheral speeds could be obtained with relatively low shaft speeds. The facing consisted of sheet cork, which was chosen as the best material on account of the friction properties and its durability.

One of these pulleys, which was to be the driven pulley of the machine, was keyed directly to the shaft of a 100-hp. Sprague dynamometer (see Fig. 1), which was used in testing only as a means of absorbing the power delivered to the driven pulley, and, although record was kept of the readings of the dynamometer, they were only used as a check and did not enter into the calculations of the test.

The other pulley, the driver, was mounted on a short countershaft held in two bronze bearings which were cast and finished specially for the purpose, the bearings being held in a pair of standard shaft hangers which were bolted to the frame. This shaft carried the driver pulley on one end, and on the other end

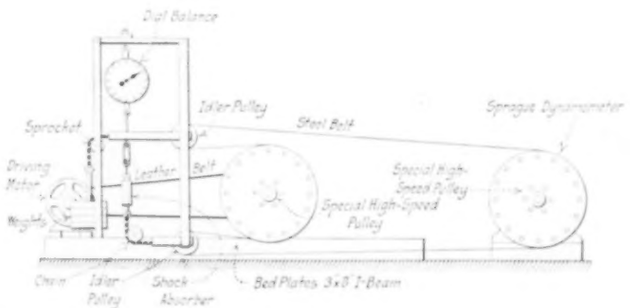


FIG. 1 DIAGRAMMATIC SKETCH OF STEEL-BELT TESTING MACHINE

the pulley with which the shaft was driven by a motor through a leather belt.

In order to measure the tensions in both sides of the steel belt, two special idlers were hung behind the driver in such a way that each one completely reversed the direction of the belt on both the tight and loose sides between the driver and the driven pulleys.

In the original design of the machine the straight sections of the belt were all to be kept parallel by using a small driver, a large driven pulley and idlers of such size that the sum of the diameters of the driver and two idlers would be equal to the diameter of the driven pulley. This arrangement was discarded because of the work which would have been necessary on the available apparatus and the belts were run with their straight sections at an angle. The manner in which this angularity was corrected for will be discussed later.

The idler pulleys were hung on swinging frames so that they were free to swing in the plane of middle of the driver and driven pulleys' faces, but were constrained from moving in any other direction. They were carried on short shafts with high-grade ball bearings in order that friction would be reduced to a minimum.

The design of these pulleys was also controlled by the high speed at which they were expected to run, and it was necessary to use a stronger material than cast iron.

Castings were made which formed the hub and a thin, solid web, and rims were made by cutting sections from a piece of heavy lap-welded 10-in. pipe. The castings and steel rings were finished all over, the proper allowance being made for a shrink fit, and the rims heated and shrunk on to the webs, after which they were again machined all over and accurately balanced.

Since it was not considered desirable that the steel belt come in contact with the steel surface of the idlers, even though slippage at this point would be very improbable, the pulley faces were covered with the same variety of sheet cork that was put on the large pulleys.

Throughout the test no trouble was encountered with the cork faces of either the idler pulleys or the large pulleys, and, although speeds as high as 12,000 ft. per min. were attained, there seemed to be no tendency for the cork to fly off.

In order that the pull exerted by the belt on the idlers could be accurately measured, yokes were put on the idler shafts around the idlers, and to these were attached link chains which passed horizontally over ball-bearing sprockets so that, when the swinging frames were in their normal position, the chains were tangent to the arc of their swing and in the same plane. The chain from the idler over which the tight side of the belt passed, hung vertically downward after passing over its sprocket, and on it was suspended a stem with a plate on its lower end and upon which weights could be placed. The chain from the other idler extended vertically upward after passing over its sprocket, and was attached to the lower part of a dial balance which measured the pull on the loose-side idler.

After starting the test it was found necessary to introduce some kind of a shock absorber to reduce the vibration of the needle on the dial balance, and for this purpose a spring balance of 200 lb. capacity was used. It was also necessary to adjust the length of this chain on account of the variations arising from difference in tension, and to do this a turnbuckle was put in between the dial and spring balances.

The swinging frames, guides, sprockets, and the dial balance were all carried on a rigid superstructure composed of iron bars and angles, and this was firmly bolted to the same I-beams which carried the shaft hangers holding the countershaft, and also the driving motor, so that there could be no relative movement between the various parts of the assembly.

The bedplates which supported this unit consisted of two 8-in. I-beams 16 ft. long, which were set at right angles to the shaft of the Sprague dynamometer and firmly bolted to the floor and shimmed with neat cement. These bedplates formed a guide upon which the driver unit was supported so that this part of the apparatus could be easily moved along the bedplate to accommodate belts of various lengths and without having to disturb the relations between the several elements of the unit.

The motor which was used to supply the driving power was a variable-speed, three-phase induction motor with speeds of 600, 900, 1200, and 1800 r.p.m., and rated at 4, 6, 8, and 12 hp. for these respective speeds. The motor was mounted on an adjustable base so that the leather belt driving the countershaft could be tightened, and the controller was mounted on the sliding frame near the motor.

The motor, which is of the most desirable type for the purpose, was not nearly large enough, and as a consequence the range of experimentation was limited by the available power supply and not by the transmission properties of the steel belt as it should have been.

Since it was necessary to make as accurate a determination as possible of the slip which occurred in the belt at all times, two similar devices were made which would electrically control two speed counters, one mounted on the center of the driver shaft and the other on the driven shaft. Two Veeder revolution counters were used for this purpose, being fixed to the shafts so that their spindles rotated on the same centers as that of the shaft; the remainder of the counter floating on the spindle and remaining stationary. On the stationary part was suspended a bar which carried an electromagnet so arranged that when current passed through the coils the movement of the armature would actuate a small lever, which slid the floating part of the counter axially so as to engage the dog clutch and count the revolutions of the spindle. Springs returned the counter to the original position and disengaged the clutch when the circuit was opened.

This arrangement gave a fairly accurate measure of speed because both instruments were made alike; and since the coils were in the same circuit and the springs of the same strength, it should give very dependable results. The difficulty, however, was not in the determination of the absolute speed, but of the difference of speed, and, since the counters only registered to the nearest revolutions and the clutches were only two-jaw clutches, there is a possibility and also a probability of an error of one revolution either way, or two revolutions, and when the slip is small, say, only 2 r.p.m., may involve an error in slip of 100 per cent, although the error involved in determining absolute speed is only a very small fraction of one per cent. In order to make accurate measurements of slip, it is evident that a differential counter should be used of such design that it would record to at least 0.10 r.p.m.

The entire testing apparatus as herein described is in itself a transmission dynamometer which measures its own losses. Having measured the tension in both the tight and the loose sides of the steel belt, and the peripheral velocity of both driving and driven pulley, the power delivered to the driving end of the belt may be computed from the value of the net pull, which is the difference between the two belt tensions and the peripheral speed of the pulley face. In a similar manner the power delivered to the driven pulley may be computed from the net pull and the peripheral velocity, the tension in the belt being uniform between pulleys, and the friction or slippage losses may be obtained from the net pull and the velocity of slip.

It is assumed that no work is done or power consumed in bending the belt, and this assumption is substantiated by the fact that the material is perfectly elastic within the limits worked, and whatever power is required to bend the belt is given back to the system when it returns to its normal condition.

In order to further verify this assumption, pieces of the belting were caused to vibrate at a very high rate of speed by holding them on the teeth of a rapidly turning sprocket. Had there been any appreciable internal friction losses present there would have been a noticeable rise in temperature in the part of the steel which was subjected to such rapid bending. Although the pieces became warm at one end from the friction of contact with the sprocket, and on the other end from impact on the material with which they were held, the part which was subjected to the severest bending remained cool.

This leaves the only losses sustained in transmitting power by steel belting to be those due to slippage of the belt on the cork surface, and since this can be reduced to practically nothing by increasing the belt tension, it appears that practically 100 per cent transmission efficiency may be obtained. The experimental results consistently verify this statement.

Belt Material and Correction for Angularity

The material which was used for the steel belts in this work was what is known in the commercial world as clock spring. It is very high-carbon steel drawn and rolled, apparently ground to size, hardened, and drawn to a dark-blue color. A rough test showed a tensile strength of slightly over 300,000 lb. per sq. in. and an elastic limit nearly as high. The material in pieces 0.01 in. thick receives no permanent set when bent around a radius of $\frac{1}{2}$ in. and snaps with a clean break when bent around a radius of $\frac{1}{8}$ in.

The chief difficulty in using such material for belting is to get a joint which will develop a sufficient proportion of the strength of the material. Considerable work was done in this connection, and, although no prediction of the durability of the joints used can be made, on account of the short duration of the test, they proved to be entirely satisfactory within the limits used, and

under conditions which were probably much more severe than would be found in an actual commercial installation.

Because of the arrangement of the pulleys, and the consequent reversal of the curvature which any part of the belt receives when passing over them, it was impossible to use the standard fastening, which consisted of a strap of a curvature equal to the smallest pulley and to which the two ends of the belt were made fast by means of screws or rivets. A later discussion of the subject of joints will describe the various ones used and show why the plain butted joint held with silver solder was the best one for the purpose.

In order to correct for the angularity of belt pull on the idler pulleys and its effect upon the readings of the dial balance and the dead weights, a method was used which calibrated the exact belt tension directly against the readings of both the dial balance and the dead weights.

A belt was put on which, instead of being spliced, had its two ends joined by a link composed of a turnbuckle and an accurate spring balance. Weights were put on the hanging platform, the swinging arms brought to their normal positions by adjusting the turnbuckle below the dial balance, and readings were taken of the dial balance and the spring balance while slowly rotating the driven wheel first in one direction and then in the other. This method divided the friction, and the average of the two readings gave the true readings which could be plotted against one another and a curve drawn from which the true belt tension could be read for any reading of the dial balance or the dead weights.

Description of Tests

On account of the limited time it was only possible to cover a small portion of the work necessary for a complete test of steel belting, and accordingly the field in which speed, horsepower, and tension are the chief variables was selected for investigation.

A series of runs was made at constant speed and, keeping one value of tension at a constant value, the load was varied from no load to an upper value limited either by the available supply of driving power or by the slippage in the steel belt.

Since the tension in the tight side, T_1, was kept constant over any run, it may readily be seen that for an increase in transmitted horsepower the factor $T_1 - T_2$ could be made larger only by decreasing T_2, and that when this quantity was reduced to a very small value the loose side of the belt would become very unstable. After covering the range of horsepower possible, the tension was changed and another run made with varying horsepower.

Having covered the desirable range of tensions, the speed was then changed and another series of runs at the new speed was made. In making a run, the apparatus was adjusted to operate under conditions of practically no load, the swinging frames on the idlers were brought into their normal position by adjusting the turnbuckles and readings were taken of r.p.m. of driver and driven pulleys, the dial balance indicating the tension in the loose side and the dead weights the tension in the tight side. In timing the r.p.m., 2-min. intervals were used in order to reduce the error due to starting and stopping the counters.

The instruments indicating the other readings were found to be exceptionally constant, and since each reading was checked by both the parties making the run, only one reading for the most part was entered on the log sheets. By taking readings of the Sprague dynamometer beam, data were made available for a calibration of this machine at low capacity values and which also served as a rough check on the other readings.

An accurate calibration was made of all the instruments used on the test, including the two spring balances, stop watch, and dead weights. The readings taken can be depended upon to have a high degree of accuracy, with the exception of the difference of r.p.m. in driver and driven pulleys. Since this is a very small value and the error involved is in starting and stopping the counters, the percentage of error in the indication of absolute speed is practically zero.

Since the readings of the tight-side tension were made with weights, they are as accurate as the weights. No difficulty was encountered in reading the dial balance to the nearest pound, and since the idlers were adjusted to their normal position for every change, the readings relative to the belt tensions should be accurate to within one per cent.

The arc of contact was measured for each belt length used. As can be seen, when the distance between centers of driver and driven pulleys is varied there will be a slight change in the arc of contact. Since this change was so small and was used only in connection with the value of slip which as explained before had a large percentage of error, the change in the arc of contact was not considered.

The following will show how the various values used were obtained from the results of the tests:

Revolutions per Minute. The difference in the readings of the positive speed counters at the beginning and at the end of the timed interval will give the r.p.m. of the driver and driven pulleys, while the difference between the values thus obtained will give the r.p.m. slip.

V_s On account of a slight difference in the circumference of the driver and driven pulleys, it was necessary to make a correction. This was made by constructing a diagram from which the velocity of slip could be read directly for any r.p.m. slip and any speed.

V_d The driver velocity is obtained by multiplying the driver r.p.m. by its circumference.

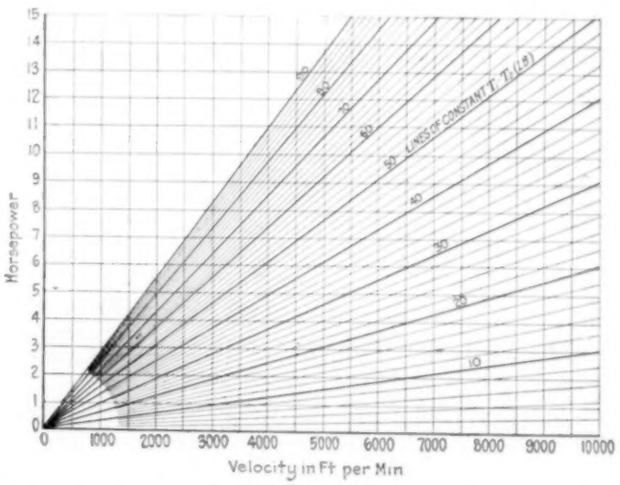


FIG. 2 DIAGRAM FOR COMPUTING HORSEPOWER FROM VELOCITY AND DIFFERENCE IN TENSION

T_1 The tension in the tight side of the belt is read directly from a calibration curve.

T_2 The tension in the loose side is also read directly from a calibration curve.

t_1 The unit tension in the tight side is found by dividing T_1 by the cross-sectional area of the belt, or

$$T_1 / 0.01 \times 0.75 = T_1 / 0.0075$$

Driver Hp. was obtained from the relation:

$$\text{Hp.} = \frac{\text{force} \times \text{distance moved per min.}}{33{,}000} = \frac{(T_1 - T_2) V_d}{33{,}000}$$

A chart was made (Fig. 2) from which the horsepower at any speed or any value of $T_1 - T_2$ may be read directly. This was done by plotting the lines Hp. $= KV_d$ for values of K corresponding to the required values of $T_1 - T_2$.

Hp. Loss. This can be obtained from Fig. 2 by using V_s in place of V_d and dividing both horizontal and vertical scales by the same power of ten.

Efficiency is computed by taking the ratio of the power input to the belt to its power output:

$$\frac{\text{Hp. driver} - \text{Hp. loss}}{\text{Hp. driver}}$$

t_c The centrifugal tension is determined from the relation:

$$t_c = \frac{WV^2}{g}$$

Fig. 3 shows a plot of this using the proper units and from which t_c for any belt speed may be read.

u The value of the coefficient of friction was calculated from the relation:

$$\log \frac{t_1 - t_c}{t_2 - t_c} = 0.4343\, u\theta$$

where u = coefficient of friction
θ = angle of contact in radians.

Discussion of Results

On account of the uncertainty of the test values of V_d it was first necessary to find, if possible, how this value varied with the others and to discover the law which connected its variation with

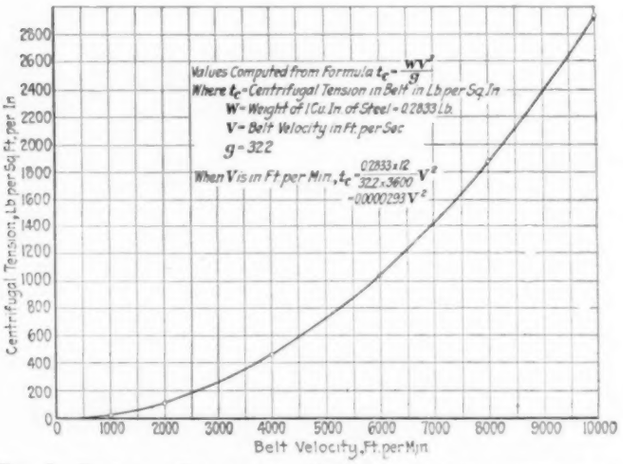

Values Computed from Formula $t_c = \frac{WV^2}{g}$
Where t_c = Centrifugal Tension in Belt in Lb per Sq In
W = Weight of 1 Cu In of Steel = 0.2833 Lb.
V = Belt Velocity in Ft per Sec
g = 32.2
When V is in Ft per Min, $t_c = \frac{0.2833 \times 12}{32.2 \times 3600} V^2 = .00000293\, V^2$
Centrifugal Tension, Lb per Sq Ft per In
Belt Velocity, Ft per Min
0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800
0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000

Fig. 3 Curve of Centrifugal Tension for Belt Speeds up to 10,000 Ft. per Min.

that of other quantities involved. The first step in this process was to plot the test values of V_d against the corresponding values of hp. This was done over the whole range of the test, one sheet for each constant, T_1. Table 1 and Fig. 4 show results and curves for $T_1 = 100$ lb.

After careful consideration of the location of these points, it seemed that the curves for all speeds for any T_1 seemed to follow a straight line beginning at the origin and then to break sharply and leave this line, the point of departure depending upon the speed, and being different for different values of T_1.

It was also noticed that for high values of T_1 the straight line from the origin was much steeper than for lower values. Working on this assumption straight lines were drawn which represented the mean of all points which seemed to locate the line. Although there is a wide variation in the location of these points, it must be remembered that the percentage of possible error in the value of V_d is very large, in fact large enough to justify the moving of practically any of the points to the mean line.

Since it was evident that some simple law existed between the various curves, as shown by the change in slope of the main straight line from the origin for different values of tension, values of V_d were plotted against their corresponding values of tension, at constant horsepower. This was done by taking the values of V_d from each curve at 10 hp. and plotting them against the value of tension corresponding to the curve.

The relation as shown from the plot proved to be a very close approximation to a straight line and accordingly the line was assumed and the lines previously located to represent the mean of the plotted points were so changed as to make their inclination to the hp. axis conform to the law. This correction was considered desirable and even necessary on account of the uncertainty in the values of V_d, which has been discussed before.

Data were now available for the construction of a characteristic diagram in which lines of constant hp. were laid down on V_d and T_1 axes. (See Fig. 5.) It was noticed on the hp.-V_d curves that

TABLE 1 DATA AND RESULTS OF TESTS ON 0.75 × 0.01-IN. STEEL BELT ($T_1 = 100$ lb.)

No. Run	R.p.m. Driver	R.p.m. Driven	Slip ft. per min.	V_d ft. per min.	T_2 lb.	Hp.-Driver	Hp. Loss	Eff., per cent	u	V_{sc}
21	243	242	4	2075	46	0.16	0.0002	99.9	0.023	0.1
	242	240	4	2055	34	0.90	0.0008	99.9	0.122	0.8
	240	239	4	2048	19	1.82	0.0031	99.8	0.317	1.7
	238	217	176	2032	3.5	2.64	0.1200	81.4	....	44.0
16	364	363	4	3110	46	0.235	0.0001	99.9	0.0240	0.3
	363	361	4	3090	33.5	1.41	0.0013	99.8	0.127	1.4
	360	359	4	3080	20.5	2.61	0.0043	99.7	0.303	2.5
	358	357	4	3060	12.5	3.32	0.0065	89.6	....	3.0
	357	295	493	3050	0.5	4.41	0.7200	83.7	....	246.5
13	485	484	0	4140	45.5	0.38	0.0001	99.9	0.097	0.4
	480	479	0	4100	32.5	1.97	0.0022	99.9	0.136	2.3
	476	472	0	4060	20.0	3.50	0.0057	99.8	0.322	3.1
	466	410	473	3990	0.0	5.85	0.7000	88.8	....	227.0
1	727	725	5	6210	36.2	2.31	0.0010	99.9	0.118	2.1
	723	721	5	6180	28.5	3.75	0.0035	99.9	0.223	3.5
	715	711	22	6110	14.5	6.30	0.0089	99.5	0.601	5.8
	709	701	57	6060	7.2	7.58	0.0706	99.1	....	10.0
	702	656	358	6060	2.5	8.37	0.4990	94.1	....	179.0
	698	607	729	6060	1.7	8.45	1.0300	87.9	....	365.0
33	1102	1099	8	9400	33.0	4.31	0.0033	99.9	0.231	3.7
	1065	1062	8	9085	21.7	7.41	0.0102	99.8	0.690	6.5
	1050	1047	9	8905	13.5	9.47	0.0170	99.8	....	8.5
	972	939	265	8205	2.7	11.44	0.0570	96.7	....	128.0

there seemed to be some symmetrical relation between the points at which the curves for different speeds broke away from the characteristic straight line. Accordingly all of these points were transferred to the V_d and T_1 diagrams, the result being a series

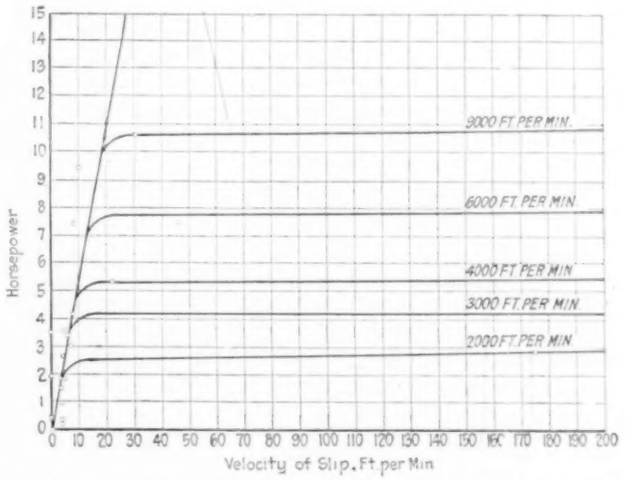


Fig. 4 Curves Showing Relation Between Velocity of Slip and Horsepower for $T_1 = 100$ Lb.

of surprisingly well-defined lines radiating from very near the origin and cutting the lines of constant hp.

Since the quantity $T_1 - T_2$ is more valuable for use in connection with this work than the quantity T_1, it was found desirable to provide some means of showing the relation of $T_1 - T_2$ to the other variables.

To do this the values of $T_1 - T_2$ were computed for various points on the diagram, and after marking the values in their proper places contours were run so as to show the lines of constant $T_1 - T_2$. The intersections of constant-hp. lines and constant-speed lines were used for this purpose and the corresponding values of $T_1 - T_2$ were computed from the following relation:

$$T_1 - T_2 = \frac{33{,}000 \times \text{Hp.}}{V_d}$$

This diagram may be used in connection with the design of a steel belt within the range of the values used, and of course applies only to steel belting of the same size as used in the test and run over cork-faced pulleys.

For any belt speed the maximum horsepower which can be transmitted with a given tension and the corresponding velocity of slip and $T_1 - T_2$ can be determined. For instance, if we wish to transmit 10 hp. we have a large range of values of both T_1 and belt speeds from which to make a choice, but when either of these values is fixed, the other assumes a definite value.

It must be remembered in using this diagram that owing to the method of its construction some of the quantities represent not the absolute values, but the limiting values corresponding to the others which have been fixed. Thus if we assume a belt speed of 6000 ft. per min. with the original assumption of 10 hp. transmitted, it will be seen that T_1 will have a value of about 135 lb. This means that with the conditions which were assumed (10 hp. and 6000 ft. per min.) any value of T_1 less than 135 lb. would be below the limiting value and that excess slip would be expected. It would be advisable, however, to use a somewhat higher tension, since in this way the velocity of slip would be materially decreased.

On the other hand, if we wished to find what speed would be necessary if we assumed T_1 to be, say, 200 lb., from the diagram it appears that a speed of about 3600 ft. per min. would be the least speed at which 10 hp. could be transmitted without excess slippage, and at this condition the slip would be about $12\frac{1}{2}$ ft. per min. Here again it would be advisable to either increase the speed or the tension, in order to work safely below the critical point, because the relations on the diagram represent conditions which correspond to the points on the straight lines of the V_s and hp. curves at which the holding power of the belt on the pulley breaks down and a very great increase in slippage begins.

By extending this diagram to cover a large range of hp., belt velocity and tension, and applying certain coefficients to compensate for changes of belt size and other variables which may occur, a complete working diagram for steel-belt design would be obtained.

The next relation which was wanted was that of the coefficient of friction to the velocity of slip. The method used in calculating

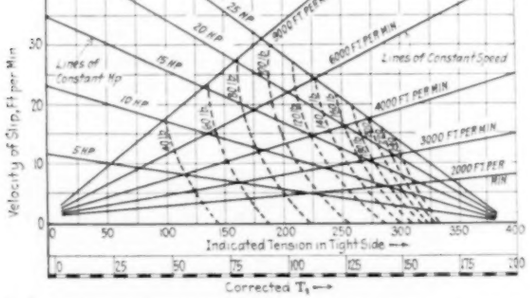


FIG. 5 CHARACTERISTIC DIAGRAM FOR STEEL BELTING

This diagram was constructed from the data and computed values obtained from the tests. It shows the relations which exist between the several variables involved, particularly as these relations are controlled by the points which determine the limiting conditions; that is, the point where excess slippage begins. The dotted lines represent lines of constant $T_1 - T_2$.

these values has been previously explained, the values of V_s used being the corrected values obtained by the method before described.

Fig. 6 shows the curves obtained, and it was found that not only does the coefficient of friction vary with the velocity of slip but also with the belt speed, increasing with increased velocity of slip and with a decrease of speed.

A rather interesting feature was discovered in connection with the computation of the values of the frictional coefficient. In using the quantity

$$\log \frac{t_1 - t_c}{t_2 - t_c}$$

it was found that for some readings the values of $t_2 - t_c$ became negative, and hence the expression

$$\frac{t_1 - t_c}{t_2 - t_c}$$

also became negative.

Investigation of the curves showed that such values appeared to develop at or near the points where the hp. and V_s curves broke away from their common characteristic line.

Very little can be determined for these values from the experimental data taken, and it is evident that such points are outside of the practical range for the use of steel belting. The phenomenon can, however, be explained as follows:

Whenever the value of t_c became greater than the existing value

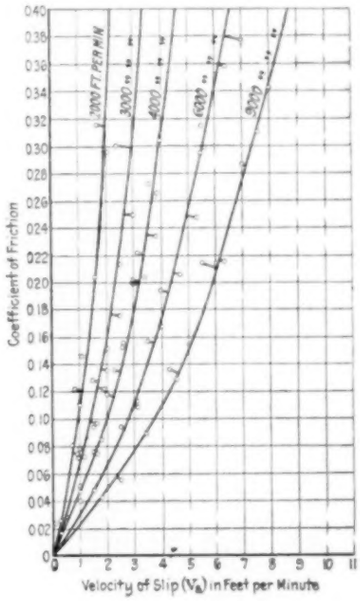

Coefficient of Friction
1000 FT. PER MIN
3000 FT. PER MIN
4000 FT. PER MIN
6000 FT. PER MIN
Velocity of Slip (Vs) in Feet per Minute

FIG. 6 CURVE SHOWING RELATION BETWEEN VELOCITY OF SLIP AND COEFFICIENT OF FRICTION

of t_2, which is the condition under which $t_2 - t_c$ is negative, it is evident that there was no force acting to keep the belt in contact with the pulley on the loose side. Accordingly, the arc of contact was diminished and conditions brought about which gave rise to the unstable and uncertain conditions which showed up in the experimental work.

In obtaining the values of the coefficient of friction an attempt was made to compute them from the relation:

$$\text{Ft-lb. lost due to friction} = u\, p\, r\, \theta\, V_s$$

where u = coefficient of friction
p = pressure per unit length of belt on pulley face
r = radius of pulley
θ = angle of contact in radians
V_s = velocity of slip.

Assuming that the total power loss due to friction is also equal to the product of the velocity of slip by the difference in tension,

$$(T_1 - T_2) V_s = u\, p\, r\, \theta\, V_s$$

and since

$$p = \frac{T_1 + T_2}{2r\theta}$$

$$V_s(T_1 - T_2) = u \frac{T_1 + T_2}{2r\theta} r\theta V_s$$

or

$$u = \frac{2(T_1 - T_2)}{(T_1 + T_2)}$$

Fig. 7 shows the curves plotted from this relation, but on account of their being independent of V_s, values of u were obtained in another manner.

Discussion of Belt Joints

One of the serious difficulties which had to be contended with was the development of some method of joining the ends of the belt in such a way as to develop a fair proportion of the tensile strength of the steel belt and at the same time not to interfere with the smooth operation of the belt and to be of such a nature that the joint will be sufficiently durable.

The following requirements are those which determined the most desirable joint to use:

a In order that there shall be the least possible amount of concentrated strain it is necessary either to have the joint extend along the belt as small an amount as possible, or to have it so constructed that its flexibility is approximately equal to that of the original belt. If the joint is of such construction that there is a distinct change in the flexibility in adjacent sections, the stresses would be so concentrated at the junction point that destructive stresses would cause an early failure of the material.

b On account of the design of the testing machine it was necessary that the joint would be capable of withstanding reversed stresses and that nothing should interfere with using both sides of the belt in contact with the pulley wheels. This condition, while

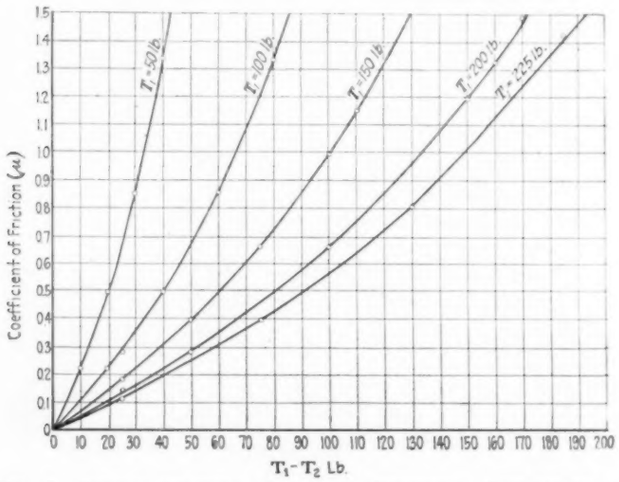


FIG. 7 CURVES SHOWING RELATION BETWEEN COEFFICIENT OF FRICTION AND DIFFERENCE OF TENSION

being essential for the test, is not necessarily applicable to all installations, because for ordinary straight drives only one side of the belt is run in contact with the pulleys.

c The material of the belt is a very high-carbon steel carefully tempered and any joint which depends upon the use of solder must be made in such a way that the original temper is either not drawn or that it is drawn to only such a degree that the material is not damaged.

It can be readily seen that a joint could not be retempered without tempering the entire belt, because there would be a section each side of the heated part which would have received enough heat to draw its temper and still would not be hot enough to harden.

Efforts were made to develop a joint which satisfied the foregoing requirements, and after much experimentation it was found that the most successful manner of joining the belt ends, so far as the test was concerned, was to make a butted joint with the edges beveled about 60 deg. and then secured by means of silver solder. Care was taken to confine the annealing effect of the soldering flame to as small a length along the belt as possible and only enough solder was used to make the joint complete. With the ¾-in. belt it was possible to confine the annealing effect to a very small length (as little as ½ in.), and to so distribute the solder that it was not necessary to do any filing in order to make the joint ready for service.

Joints of this kind were used throughout the test with apparently no signs of weakening or failure and showing no undesirable effects on the running stability of the belt.

An attempt was made to weld the belting by means of an oxy-acetylene torch, but on account of the extreme thinness of the material and the high temperature required it was unsuccessful.

In an attempt to make a joint which would develop a large percentage of the original strength of the material, one of the ends to be joined was cut to a sharp V and the edges serrated, and the other end so cut as to interlock with it. It was expected that when this joint was silver-soldered the strain would be taken up by the material instead of by the solder as it would be with the simple butt-soldered joint. This method was not a success, because when heated to a sufficiently high temperature to flow the solder it buckled and twisted and could not be made flat.

Riveted joints were also tried and proved fairly satisfactory. The joints were made in the V-shape in order to distribute the rivets and both ends were cut out so that the tendency to stiffen the joint would be reduced to a minimum. They were made by the use of a punching die into which one end of the belt was clamped and 15 No. 50 holes were punched. The other end was punched in the same die, being put through from the opposite end so that the holes in the two pieces exactly matched. The rivets used were No. 51 punchings from phosphor bronze about 0.03 in. thick. These were placed in the holes and headed down lightly on both sides, care being taken not to stretch the material by upsetting them too much. A joint of this type was run for a considerable length of time and then a very small crack was discovered in the edge. It is the opinion of the authors that with sufficient care and experimentation a very satisfactory riveted joint could be developed.

PART II INVESTIGATION OF SLIP

IN carrying out the work described in Part I both Hampton and Leh realized that certain relationships existed between the horsepower transmitted by the belt, velocity of slip of the belt on the pulleys, and the coefficient of friction, but owing to the very large error in their observed data on velocity of slip, they were unable to find such expressions as have been developed below.

The difference of r.p.m. of the driver and driven pulleys as observed by the above authors was subject to a large error in that the revolution counters used did not read less than unity. One revolution would correspond to a slip of 8.625 ft. per min. were the observation period one minute long, as the circumference of both pulleys was 8.625 ft.

Hampton, realizing that more accurate apparatus was necessary to measure the slip, designed and partly constructed a differential revolution counter that was completed by the author. This revolution counter would indicate one one-hundredth of one revolution difference, with a probable error of 5 per cent.

The Differential Revolution Counter

The positions of the idler pulleys reverse the direction of the belt, and hence the direction of rotation of the driver and driven pulleys is opposite. The mechanism of the differential, as is commonly known, is such that the two wheel shafts rotate in opposite directions and with equal r.p.m. when there is no rotation of the ring gear. The driver and driven shafts are connected 1 to 1 to the wheel shafts by light chains and sprockets. Hence, if the driver and driven pulleys are rotating with the same speed, the ring gear is stationary. The pulleys having equal circumferences, no slip would be in evidence when this were the case. However, as soon as the belt began to slip, the ring gear would rotate in proportion to the difference of peripheral velocity of the two pulleys.

The ratio of the ring gear to the pinion is 1 to 20, and that of the differential gears is 1 to 1, making the ratio of the wheel shaft to the ring pinion 1 to 10. A disengaging coupling is connected to the ring pinion, by means of 1-to-1 sprockets and light chain, and is operated by the solenoid which in turn is controlled by the knife switch. This coupling has twelve teeth on one side and a knife edge on the other, making the probable error 1/24 or 4.16 per cent. In order that the chain be kept tight, a friction brake was put in between the sprocket mounted on this coupling shaft, and its supporting standard.

The revolution counter used was one specially constructed for this particular use. The unit wheel being divided into tenths gave a ratio of 1 to 100 from the wheel shaft to the counter. Hence the difference of r.p.m. of the driver and driven shafts was determined quite accurately, that is, to one one-hundredth of a revolution, which in terms of the pulley circumference is 0.0863 ft.

It was found after running some time that the vibration of the chains connecting the pulley shafts to the revolution counter caused them to become stretched in places, effecting a slight rotation of the ring gear first in one direction and then in the opposite. This appeared to vary with the speed, but, as nearly as could be determined, a probable error of from 1 to 2 per cent might be introduced.

Through all tests this machine served its purpose very accurately and was a great help in adjusting the load on the Sprague dynamometer, for the point at which the belt began to slip excessively could be observed at a glance. Without this machine the data on the slippage of the belt would be so inaccurate that the results of the tests would have been useless.

Belt Material and Joints

The material used for belting in this test was clock-spring steel ¾ in. by 0.01 in. It is manufactured in this country from Swedish high-carbon charcoal steel, drawn, rolled, ground to size and tempered to a dark blue. It can be obtained in widths of from ½ in. to 3 in. and 0.01 in. thick and costs from 6 to 18 cents per ft.

Tests of this material show the ultimate strength to be over 300,000 lb. per sq. in. and the elastic limit slightly less. The belt used in this test had no permanent set when bent around a radius of ¾ in. but it was found it would rupture when bent around a radius of $\frac{1}{16}$ in.

When the belt bends around a pulley, as much work is put into bending it as appears when the belt straightens out on leaving the pulley. This is not true of any other kind of belt, as power is required to bend it and again to straighten it out.

The joint used on the belt tested was a silver-soldered lap joint. It proved very satisfactory throughout all tests and showed no

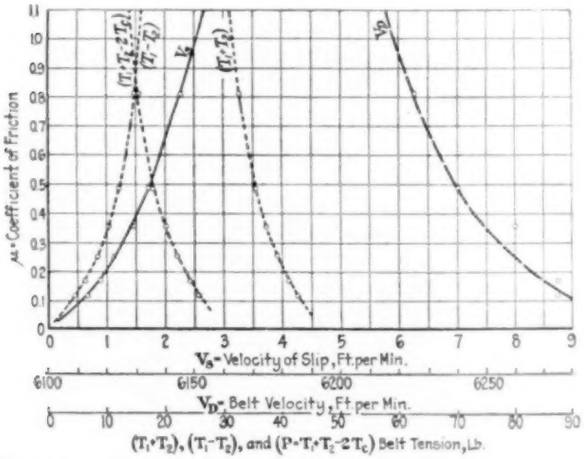

μ = Coefficient of Friction
Vs = Velocity of Slip, Ft. per Min.
VD = Belt Velocity, Ft. per Min.
(T1+T2), (T1-T2), and (P+T1+T2-2Tc) Belt Tension, Lb.

FIG. 8 CHARACTERISTICS OF A 0.75-IN. BY 0.01-IN. STEEL BELT

signs of necking-in where the temper had been drawn. These joints when tested have an efficiency of about 60 to 65 per cent in pure tension, the rupture taking place on either side of the lap where the metal has been softened.

Owing to the low efficiency of the silver-soldered and brazed joints, a dozen or more riveted joints were constructed. Phosphor-bronze rivets were used and one triple-riveted lap joint by test had an efficiency of 84 per cent, rupture occurring by shearing all the rivets. This joint could not be used on pulleys smaller than 30 in. in diameter.

Other similar lap joints averaged 76 per cent by test when cold-drawn iron wire was used for rivet material.

Owing to the idler pulleys reversing the motion, one side of the belt runs on the driven pulley and the other side on the driver pulley, consequently it was necessary to have both sides of the belt joint as smooth as possible.

The type of joint used in an installation of steel belting in one of the shops was of the bent cover-plate type and would have been quite successful had the pulley on the motor been of larger diameter. This cover plate was bent to conform with the curvature of the smaller pulley, and the ends were bent up on a radius of ¾ in. It appeared that the tangential acceleration of the joint as it came on to the motor pulley kept the joint from following the pulley curvature. This induced flexure in the belt, just ahead of the first row of rivets, and the combined stress of the tension and flexure being in the neighborhood of the elastic limit caused rupture after 15 to 20 hr. operation.

It is the opinion of the author that this type of cover-plate joint would be quite satisfactory for use on pulleys of not smaller radius than 15 in.

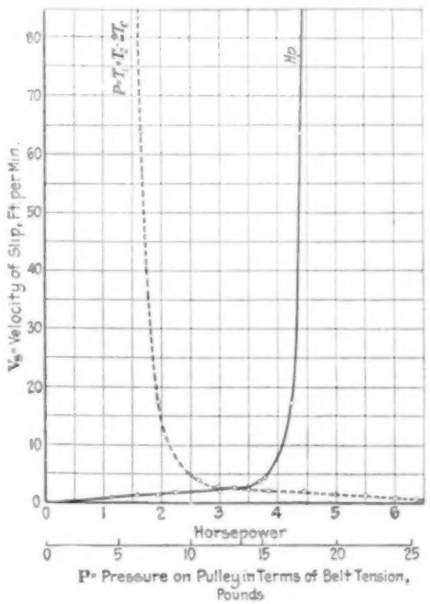


FIG. 9 CHARACTERISTICS OF A 0.75-IN. BY 0.01-IN. STEEL BELT

Description of Tests

The calibration of the weights and spring balance was made just after the differential revolution counter was completed. The work checked quite well with the calibration made by Hampton and Leh.

Several preliminary runs were then made to determine the capacity of the motor and the variations of speed with load. A preliminary curve run was then made. A tension of 23.6 lb. in the tight side of the belt was selected in order that the tension in the loose side could be made practically zero, allowing an excessive slip. The speed selected would also bring in the characteristics of the motor and allow a certain change in the centrifugal tension of the belt. The curves resulting from this set of values and shown in Figs. 8 and 9 will be discussed below.

The four speeds of the motor with the arrangement of pulleys then on the machine would give belt speeds of about 3150, 4770, 6250 and 9450 ft. per min. In order that a wider range of belt speeds could be obtained, a large pulley and a small pulley could be placed on the driver-pulley shaft, and with these pulleys belt speeds of 2080 and 14,500 ft. per min. could be obtained.

Seven runs were made with each velocity for various tensions in the tight side of the belt. The smallest is 23.6 lb. and corresponds to 50 lb. on the weight pan, while the largest is 111.6 lb.

and corresponds to 225 lb. on the weight pan. The interpolated results for $T_1 = 99.0$ are given in Table 2.

The run was always begun at the highest horsepower possible, and from five to six observations made as the hp. varied to zero. The load could be held quite constant throughout each run when the Sprague dynamometer was separately excited, but near the end of the test period, when the generator was self-excited, some difficulty was experienced in making all the observations. Before a run was begun, the surfaces of the cork pulleys were always cleaned in order that the conditions of the test might be the same.

The following values were observed and will be discussed below:

$(T)_1$ = tension in lb. on the idler over which the tight side of the belt passes; observed by the weights on the weight pan

T_1 = corrected tension in the belt in lb. as taken from the calibration curves

$(T)_2$ = tension in lb. on the idler over which the loose side of the belt passes; observed by the reading of the spring balance

T_2 = corrected tension in the belt in lb. as taken from the calibration curves

N = r.p.m. of the driver pulley; observed from the reading of the electrically operated Veeder revolution counter

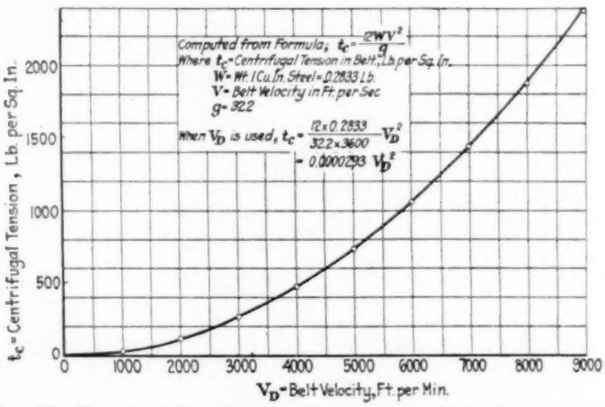


FIG. 10 CURVE OF CENTRIFUGAL TENSION FOR BELT SPEEDS UP TO 9000 FT. PER MIN.

n = difference of r.p.m. of the driver and driven pulleys as observed from the differential revolution counter.

A reading of the brake arm on the Sprague dynamometer was also taken and used as a check on the power transmitted.

NOTATION

T_1 = actual tension in the tight side of the belt in lb.

t_1 = actual unit tension in the tight side of the belt in lb. per sq. in.

T_2 = actual tension in the loose side of the belt in lb.

t_2 = actual unit tension in the loose side of the belt in lb. per sq. in.

T_c = centrifugal tension corresponding to the velocity at which the belt is passing around the pulleys in lb.

t_c = actual unit centrifugal tension in lb. per sq. in.

$T_1 - T_2$ = difference in belt tensions in lb. or the useful force in the transmission of power.

V_d = belt velocity in ft. per min.

V_s = computed velocity of slip of the belt relative to the pulley in ft. per min.

V_{sc} = velocity of slip of the belt in ft. per min. corrected from the curves where $\text{Hp.} = 0.17 T_1^{0.66} \times V_s$

P = actual tension in belt producing pressure on pulley, lb.

p = pressure in lb. per sq. in. per unit length of belt on the pulley face

W = weight of 1 cu. in. of steel in lb.

g = gravitational force

r = radius of driver and driven pulleys in ft.

u = coefficient of friction

θ = angle of contact in radians the belt makes on the pulley face.

TABLE 2 DATA AND RESULTS OF TEST ON 0.75 x 0.01-IN. STEEL BELT

Run No.	T_1	T_2*	P	V_d*	Hp.	u	V_{sc}
R-4	99.0	22.6	120	2018	4.67	0.482	1.37
	....	23.4	...	3000	6.98	0.481	2.05
	....	29.0	...	4600	9.76	0.440	2.88
	....	35.6	...	5750	11.03	0.376	3.24
	....	56.4	...	8920	12.76	0.236	3.76
	99.0	43.0	140	2033	3.45	0.269	1.01
	....	45.0	...	3070	5.25	0.260	1.48
	....	50.0	...	4610	6.84	0.234	2.00
	....	57.0	...	6040	7.69	0.162	2.26
	....	79.0	...	9300	5.64	0.092	1.66
	99.0	63.0	160	2068	2.255	0.145	0.66
	....	65.0	...	3100	3.195	0.137	0.93
	....	70.0	...	4680	2.980	0.117	0.87
	....	78.0	...	6200	3.950	0.084	1.16
	99.0	83.0	180	2075	1.005	0.057	0.30
	....	85.6	...	3163	1.286	0.046	0.84
	....	90.8	...	4740	1.178	0.029	0.35
	....	98.0	...	6250	0.189	0.004	0.05

* Interpolated values.

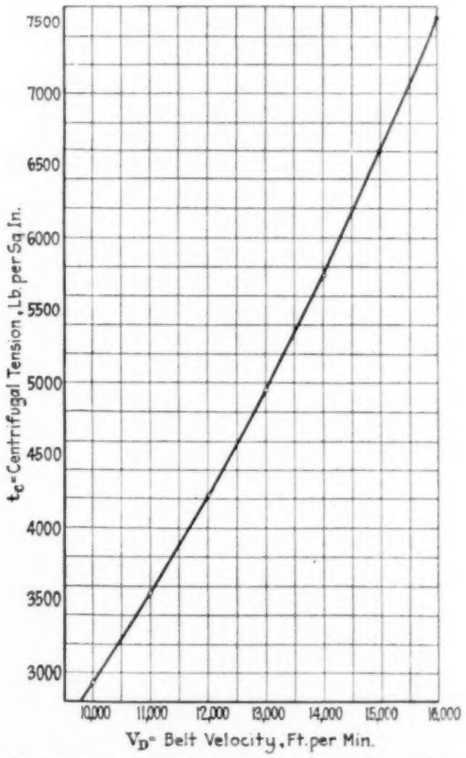


FIG. 11 CURVE OF CENTRIFUGAL TENSION FOR BELT SPEEDS UP TO 16,000 FT. PER MIN.

DISCUSSION OF CURVES

The computations necessary in working out a set of values involved a great number of operations. An attempt was made to plot curves of various functions that would constantly enter into certain equations.

The values of t_c and T_c were first computed and plotted as shown in Figs. 10, 11, and 12. The equation for unit centrifugal tension is

$$t_c = \frac{12WV_d^2}{g}$$

where $W = 0.2833$ lb.

$g = 32.2$

and in this equation V_d is in ft. per sec. If V_d is to be used in ft. per min., the equation becomes

$$t_c = \frac{12 \times 0.2833 \times V^2_d}{32.2 \times 3600}$$
$$= 0.0000293\ V^2_d \text{ lb. per sq. in.}$$

As $T_c = t_c \times A$, the multiplying factor then becomes

$$T_c = 0.0000293 \times 0.01 \times 0.75 \times V^2_d$$
$$= 0.000000022 V^2_d$$

Computations of all observed data were then made and the results tabulated, the equations employed being given below.

Circumference of driver and driven pulleys = 8.625 ft.

$$V_d = \left(N - \frac{n}{2} \right) \times 8.625 \text{ ft. per min.}$$

$$t_1 = \frac{T_1}{0.0075} \text{ lb. per sq. in.}$$

$$\text{Hp.} = \frac{(T_1 - T_2) V_d}{33{,}000}$$

where $T_1 - T_2$ = force in lb.

V_d = distance

$$\text{Efficiency} = \frac{\text{Hp.} - (T_1 - T_2) V_{sc}}{\text{Hp.}} \times 100 \text{ per cent}$$

$$u = \frac{\log_{10} \frac{t_1 - t_c}{t_2 - t_c}}{0.43430}$$

$$V_s = \frac{n}{2} \times 8.625 \text{ ft. per min.}$$

The above equation for u is derived in Smith and Marx' Machine Design.

Curves of all relations that might possibly exist were then plotted as are shown in Figs. 8 and 9.

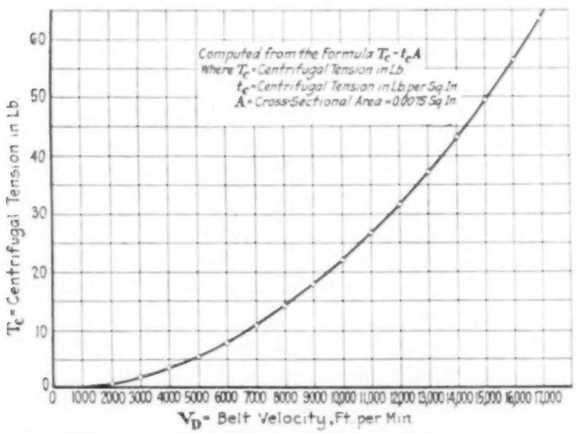

Computed from the formula $T_c = t_c A$
Where T_c = Centrifugal Tension in Lb.
t_c = Centrifugal Tension in Lb. per Sq. In.
A = Cross-Sectional Area = 0.0075 Sq. In.
T_c = Centrifugal Tension in Lb.
V_D = Belt Velocity, Ft. per Min.

FIG. 12 CURVE OF CENTRIFUGAL TENSION FOR BELT SPEEDS UP TO 17,000 FT. PER MIN.

The most noticeable relation is that of velocity of slip and horsepower. This curve shows practically straight-line variation up to a certain point where the velocity of slip increases very suddenly. Inspection of the data shows that at this point $t_2 = t_c$ and hence there is no pressure on the pulley where the belt leaves the driven pulley. As this is the case, it would be expected that the velocity of slip would become excessive.

The curve of P as a function of slip shows that the pressure decreases with an increase of slip up to a point where the pressure decreases but slightly with a large increase of slip. As can be seen from these two curves, the pressure on the pulley and the horsepower are related, but for the present the most striking relation appears to be in the curve of horsepower and slip.

The relation between the coefficient of friction and velocity of slip apparently exists in Fig. 8. This is a misconception, for the curve should not pass through zero, since the coefficient of friction of rest between cork and steel is not zero. All that this curve indicates is that the coefficient of friction at zero velocity and zero slip is indeterminable, due to other variables. It may also be noted that the belt velocity is not constant and that the pressure varies.

A relation between u and $T_1 + T_2$ was suspected, but after some investigation it appeared that T_c entered into this factor. It was then that the pressure curve was plotted, and although it has no significance as it appears here, it was necessary in the work that was to follow.

METHOD OF OBTAINING RESULTS

The first relation that was attempted was that between hp. and

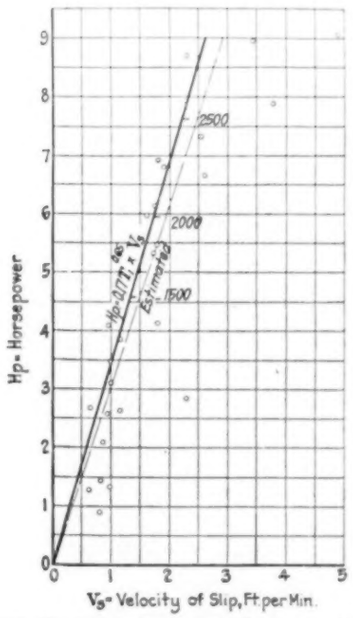


FIG. 13 CURVES SHOWING RELATION BETWEEN VELOCITY OF SLIP AND HORSEPOWER

V_s. It was noticed that for a constant value of T_1 all the points up to certain limits would fall on a straight line. These curves were plotted, the curve for $T_1 = 99$ lb. being shown in Fig. 13. A dashed line was then drawn such that the estimated slope would as nearly as possible coincide with the mean average of the points. In these curves this line is a light dashed one and noted by the word "Estimated." It must be remembered that in these curves all points in the vicinity or above that where $t_2 = t_c$ are not plotted. The figures on the right show the belt velocity and hp. at which $t_2 = t_c$.

When this was done for all values of T_1, the slope was found and tabulated with the corresponding value of T_1. The equation of a straight line passing through zero is $Y = mX$, where m = slope. With this in mind the slope m was plotted as a function of T_1, and resulted in a parabolic curve. To determine the equation of this new curve the data were plotted on logarithmic cross-section paper. The result was a straight line which had 0.17 for its intercept and a slope of 0.65, indicating that the slope m was equal to $0.17\ T_1^{0.65}$.

From this it was a simple matter to deduce the equation—

$$\text{Hp.} = 0.17\ T_1^{0.65} V_s$$

As all of the points of the estimated slope m did not fall on the logarithmic curve, another line, the slope of which was computed from the above equation, was drawn on the curves and noted by the equation.

The values of the velocity of slip were then corrected by the use of these curves and the corrected value was tabulated as V_{sc}.

Fig. 13 was then plotted to give an idea of the relation of hp. to V_{sc} at various values of T_1. The lines of constant T_1 are shown as solid straight lines. The light dashed lines are lines of constant

V_d and the points of intersection with the lines of constant V_d were computed from the equations—

$$\text{Hp.} = (T_1 - T_2) \times V_d$$
$$T_2 = T_c = 0.00000022\ V^2_d$$

The relation of u to V_{sc}, V_d and P was more difficult to determine owing to the large number of variables. An attempt was made to select groups of values from the observed data where two of the values remained constant. This could not be done for enough values to find a relationship between the other two variables, and for a time the solution looked much more difficult. It seemed that new data must be taken or that interpolations must be made from the data already at hand. As the taking of new data, such that two of the variables remain constant, was impractical for but one observer, interpolated data had to be computed. The values of T_2 and V_d were interpolated from curves and the observed data.

A large number of groups were selected, and in each group two and sometimes three sets of values of the two variables could be obtained when the other two remained constant. These values were plotted on logarithmic cross-section paper and were found to be straight lines having approximately the same slope. For example, the relationship between u and V_{sc} is shown in Table 3 for one value of P throughout the set of groups.

TABLE 3 RELATIONSHIP BETWEEN u AND V_{sc}

Run No.	Constants		Variables		Relation
	P	V_d	u	V_{sc}	
R-1	70	5000	0.143	1.20	
R-2	..	....	0.360	2.75	$u = 0.1\ V_{sc}^{1.37}$
R-1	..	4000	0.190	1.15	
R-2	..	....	0.465	2.25	$u = 0.155\ V_{sc}^{1.37}$
R-1	..	3000	0.271	1.00	
R-2	..	....	0.515	1.80	$u = 0.223\ V_{sc}^{1.37}$
R-1	..	2000	0.240	0.75	
R-2	..	....	0.550	1.25	$u = 0.386\ V_{sc}^{1.37}$

Data similar to those in Table 3 were obtained for pressures of other values and the relation found. The exponents in each were averaged and found to be 1.37, it then being evident that

$$u = V_{sc}^{1.37} \times f(P) \times K \times f(V_d)$$

where K is some constant.

The characteristics of the curves plotted of u as a function of V_d and P when V_{sc} was constant, showed that V_d and P varied inversely according to some power. Interpolations and computations similar to the above were made, and it was found that u varied inversely as some constant multiplied by the square root of P. Again the same methods were followed, and it was found that u varied inversely as some constant multiplied by $V_d^{1.6}$.

This gave the equation

$$u = \frac{V_{sc}^{1.37} \times K}{p^{0.5} \times V_d^{1.6}}$$

and 75 values of K were solved from the equation

$$K = \frac{u \times p^{0.5} \times V_d^{1.6}}{V_{sc}^{1.37}}$$

The values varied from 2.71×10^5 as a minimum to 4.04×10^5 as a maximum. The majority, however, were in the neighborhood of the average, which was 3.1992×10^5.

The final deduction of the relation of u to the other variables is given by the equation

$$u = \frac{V_{sc}^{1.37} \times 3.2 \times 10^5}{p^{0.5} \times V_d^{1.6}}$$

CONCLUSIONS

The first equation found in this investigation is useful in determining the tension in the tight side of the belt, when a given amount of power is to be transmitted and a reasonable velocity of slip (not greater than 3 ft. per min.) is assumed. The wear on the pulley facings is in proportion to the velocity of slip, and hence it is advisable to keep this value as low as possible to prevent wear. Knowing this tension, the belt may be cut to length by computing the total elongation due to the tension, and the distance that the cork will be depressed due to this tension. The belt may then be joined and placed on the pulleys.

The second equation, while not as practical as the first, is interesting from the technical nature with which the different factors vary the value of the coefficient of friction as the range of power transmission is passed over. The coefficient of friction of rest between cork and steel at a given pressure would not appear to be zero as this equation would indicate were the velocity of slip zero.

The efficiency of transmission was always so near 100 per cent that it was not tabulated in the data. Only in extreme cases did it fall below 98 per cent, and the author spent but little time on this computation.

BIBLIOGRAPHY

Tests by Eloesser, in Germany, forming the basis of the subject.
Engineering News, Jan. 9, 1908.
Engineering News, Oct. 14, 1909. Article by Shroeter.
Power, May 3, 1910. Article by Krall.
Tests by General Electric Co. Not published.
American Machinist, Nov. 21, 1912. Article by Conkhete.
Machinery, Feb., 1913. U. S. Consul F. D. Hale.
Machinery, May, 1914. Editorial.
American Machinist, May 14, 1914. Article by Chubb.
Steel Belting. A Thesis by Hampton and Leh, Stanford Univ., Cal.

A paper on Recent Advances in Utilization of Water Power, by Eric M. Bergstrom, of London, read before the Institution of Mechanical Engineers, January 23, 1920, directs attention to the main lines along which the development of this highly-specialized branch of engineering has taken place, and indicates briefly its general effect on the utilization of water power. In considering these developments as described in the paper, Mr. Bergstrom summarizes the outstanding features as follows:

a The exclusive use of two types of turbines only, namely, Francis reaction turbines for low and medium heads and Pelton impulse wheels for high heads

b The extension of the use of Francis turbines under heads approaching 800 ft. and Pelton wheels in single stage up to 5500 ft.

c The exclusive adoption of balanced wicket gates for the regulation of Francis turbines and the circular nozzle with combined deflector and needle regulation for Pelton wheels

d The standardization of turbine runners and increased specific speed permitting the use of single vertical units of large output under low heads

e The general increase of output per unit, the maximum output at present being 31,200 hp.

f The general increase of the overall efficiency of about 6 per cent to 10 per cent

g The exclusive use of oil-pressure governors

h The efficient regulation (by means of differential surge tanks) of turbines using long pipe lines

i The employment of large-diameter pipe lines under high heads, resulting in an appreciable reduction of the initial cost of development.

These developments, coupled with the improved construction of impounding dams in addition to multifarious improvements in details to insure effective safeguards and reliability in operation, constitute as such an enormous advance from a purely technical point of view, but of even greater significance has been the unlimited field thereby opened up for the application of electricity and the extended scope given to the utilization of water power in the service of civilization; issues of the greatest magnitude have been raised affecting the economic life and future prosperity of nations, and from being a question to be left solely to private enterprise, the control and development of water power now rank among the vital problems of national interest.

Design of Ore Fleet for Upper Mississippi

Economy of River Transportation of Ore as Shown by Experimental Trips on Upper Mississippi River—Particulars Regarding Design and Construction of Barges and Towboats—Terminal Facilities Projected, etc.

By WILLIAM S. MITCHELL,[1] ST. LOUIS, MO.

This paper deals principally with the design of an ore fleet for the upper Mississippi River. The author describes two experimental trips which were conducted during the war to try out the possibilities of such transportation on the Mississippi. The results of these experimental trips warranted the construction of a fleet of 24 barges and 4 towboats for traffic of ore and fuel on the upper Mississippi River. The writer, as engineer of the U. S. Engineer Office at St. Louis, was in charge of the design of these vessels and describes the difficulties encountered and the manner in which they were handled. He also gives information concerning the fleets for the lower Mississippi River and the Warrior River, and the terminal facilities being developed in cities and towns along these rivers.

IN the Spring of 1917, after this country had entered into the world war, it was quickly realized that the transportation of materials for the manufacture of munitions and equipment presented one of the most important problems to be solved, especially as the movement of large bodies of troops and their impedimenta soon began to crowd and embarrass the railroads to the point of breakdown. For relief, in part, the use of the waterways was early suggested, and in May of that year a decision was reached by the War Department, with this idea in view, to aid in transportation on the Upper Mississippi River of iron ore from Minnesota ore fields to the coal fields of the Middle West, to increase, in blast furnaces there, the production of pig iron for the manufacture of steel near St. Louis. This effort started with a small improvised fleet composed of six steel barges of the U. S. Engineer District at St. Louis, each of 600 tons capacity, and a steel-hull stern-paddle-wheel towboat of ordinary western river type, from the Mississippi River Commission. This fleet was assigned to a lessee to try out the possibilities of the upper river for such traffic, and, loaded with about 3000 tons of Illinois coal to be sold at St. Paul to meet in part the expense of the undertaking, left St. Louis July 31, at the beginning of the annual low-water season, and proceeded without incident upstream, arriving at destination in the middle of August.

At St. Paul considerable delay ensued in unloading at the water front the unusual quantity of coal, and in obtaining and loading ore for the return trip. An extra quantity of ore having been delivered by error of the railroad and ore companies, four more small wooden barges were borrowed at St. Paul from the Engineer Department, for its transport, and were added for the downstream trip to the tow, already rather too large and heavily laden for the prevailing river stage, which had been falling steadily until the conditions almost reached the recorded low limits for a navigable season.

The whole fleet, with about 3400 tons of ore, left St. Paul August 28, and although the draft of the barges was at the extreme limit permitted by the channel depths, they were floated over the shoals and bars with fair success; but the towboat, built for the deeper water of the lower river, was of slightly greater draft, passing that limit, and grounded at nearly every river bar encountered. Then, too, as the boat was nearly touching bottom at many other places, it lost control of the tow, and the barges also were frequently grounded in the soft river sand. Other smaller and lighter-draft boats were brought to the assistance of the struggling fleet, and after two months of incessant effort the vessels arrived at St. Louis.

Meanwhile a similar second fleet had been collected at St. Louis and, loaded somewhat more lightly with coal, had started north, but because of the fallen river it was unable to proceed much beyond the mouth of the Illinois River, to which stream it was diverted, and after discharging cargo at Hennepin it returned to St. Louis.

The seemingly disastrous southbound trip from St. Paul unfortunately created a strong impression of unsuitability of river transportation to modern needs; but as a matter of fact, that trip, made at such an extraordinarily low stage, developed practically and commercially the fact of an excellent, well-improved river channel for nearly 700 miles between the cities named, available to at least 4 ft. depth for wide tows of barges during the low-water season, increasing at high stages to 8 and 9 ft., which guarantees to vessels built specially for such shoal depths a capacity for transportation far beyond that of any railroad. As the route by rail from the Minnesota ore fields to St. Paul and thence by river 675 miles to St. Louis is about 200 miles shorter than the prevailing route by rail to the lakes and thence by water to southern lake ports and again by rail to St. Louis; and as the ore is always at hand in full-capacity quantities for the down trip, and the coal, eagerly sought in the north, is equally plentiful for the upstream haul, there is offered an ideally balanced through traffic, commercially profitable even with these low-grade (tariff) commodities, which, if continually carried in large quantities, cannot fail to effect great economy in the transportation costs of both.

Upper Mississippi Fleet

As a war measure, to increase the production of pig metal and in contribution to the relief of the acutely felt shortage in ore and coal cars, the United States Shipping Board, Emergency Fleet Corporation, made an allotment of $3,360,000 for the construction of 24 barges and 4 towboats, to be entirely of steel, and specially designed for this through traffic of ore and fuel on the shallow Upper Mississippi River. The number of barges was afterward reduced to 19 and the funds increased to $3,860,000 to aid in the construction of terminal loading and unloading apparatus.

Design and Construction of Barges

The design of the vessels fell to the writer's charge under the U. S. Engineer Office at St. Louis, under the War Department, and in this work most valuable counsel and assistance was freely given by Mr. M. H. Von Pagenhardt, Naval Architect, formerly with the Kansas City-Missouri River Navigation Co., and by Mr. J. W. Gerell, Naval Architect, Mississippi River Commission, both at St. Louis.

As is well known, large barges offer (*a*) greater carrying capacity per unit of fleet area and draft, (*b*) lower cost for construction and upkeep, and (*c*) less resistance in propulsion with consequent reduction in transportation cost per unit of capacity than a fleet of smaller vessels aggregating the same capacity. With these considerations in view, the dimensions of the barges were fixed just within the physical limits set by bridges and locks in the river reach to be navigated.

The dimensions chosen for the barges were 300 ft. length, 48 ft. width or beam, and 10 ft. depth. The length, 300 ft., of the locks on the rapids at Moline and Le Claire fixed the length of the component barges. The minimum channel clearance for the bridges, with one exception, is about 150 ft., thus the width of a unit fleet or tow was limited to about 144 ft. A width of 48 ft. allowed three barges to be grouped about each towboat, the most advantageous arrangement in towing, without necessity of breaking tow when running through the many bridges. The depth provided the necessary longitudinal strength and stiffness of hull.

With these dimensions it was found that such a barge would

[1] Principal Assistant Engineer, U. S. Engineer Office.

Abstract of a paper presented at the Spring Meeting, St. Louis, Mo., May 24 to 27, 1920, of The American Society of Mechanical Engineers, New York. All papers are subject to revision.

carry about 850 tons of cargo on a draft of 4 ft. during low water, increasing at high stages to 2500 tons on 8-ft. draft when going upstream, and to 3000 tons on 9-ft. draft when floating over the bars coming downstream. It was estimated that the annual average load would be 1500 tons per barge, making 4500 tons per tow each way, and also, that about 16 round trips for each boat could be made during the boating season of 7 to 8 months, giving a unit annual capacity to each towboat of 144,000 tons, or, 576,000 tons to be moved by the fleet annually between the cities. The barges, therefore, were laid down on this basis.

It was found that Minnesota ore at about 115 lb. per cu. ft. could be readily carried as a deck load to the capacity limits assigned by the construction of necessary bulwarks 5 ft. high entirely around the barge. Also this would permit the use of the full unbroken deck as an upper chord to the barge considered as a girder, giving the desired longitudinal strength of structure with minimum weight of metal. But the full deck had to be abandoned as the upstream capacity cargo of coal could not be adjusted to these conditions, because the much greater bulk of coal per ton (about 55 lb. per cu. ft.) would require piling so high above deck as to be dangerous, and this compelled sinking the latter in the form of a great hopper, or open hold, 5 ft. deep, the barge thus losing longitudinally the strength of the sunken part of the deck which becomes the hopper bottom near the neutral axis of the vessel.

Longitudinal strength of structure was therefore given by wide (6 ft.) deck stringers on each side of the hopper, increased by a steel combing 1 ft. high above deck, running entirely around the hopper and adding to the depth of the latter.

The final dimensions of the cargo hopper are: an unbroken length of 256 ft., 36 ft. width, and 6 ft. depth. The hopper is drained at the corners and middle of each side by 4-in. drain pipes passing through the barge at about the 4-ft. draft line, and controlled from the main deck by proper valves. The hopper bottom is of ¼-in. plate, supported on longitudinal 6-in. channels spaced 12-in. centers as deck reinforces, to withstand inevitable careless handling of heavy clamshell unloaders.

The open hopper, of course, is suitable for carrying any other materials or commodities not requiring protection from the weather, either in bulk or manufactured, as clay products, brick and tile, structural steel and machinery, lumber, ore, stone, etc.

The form of the barges, in section, thus given by the hopper, is that of two side pontoons, each 6 ft. wide by 10 ft. deep, connected by a double bottom 36 ft. wide by 5 ft. deep, and in the bottom and pontoons, which latter act also as expansion tanks, there is stowage space for 1500 tons of oils or nearly 2000 tons of bulk molasses "blackjack" now beginning to move to this country from the West Indies via New Orleans. Liquid cargoes are to be loaded and discharged by a 6-in. pipe system, with suction and discharge valves in each barge compartment, operated independently by a large steam pump, and also by hand pumps, installed in one fore peak of the barge, steam supply being had from the towboat or from steam plant on the loading or discharging dock. The pipe system can be used also as a bilge system.

In addition there is a smaller pipe system, with fusible plugs and nozzles, passing under deck for steam supply to each compartment for fire smothering, and the compartments are entered through water-tight deck hatches, fitted with ladders, and are vented for oil evaporation by goose-neck pipe vents through the decks of the side pontoons close to the hopper combing, the mouths of the vents being carefully screened by fine-mesh copper netting, and closed against water ingress by balsa wood ball float valves soaked in linseed oil and varnished to prevent weather checking.

The barges are fitted at each end with hand capstans, hawsers, steel anchor cable, cable reels and stoppers, heavy stockless anchors handled from davits with blocks and falls, towing bitts and numerous kevels, chocks, side fenders, etc.

The straight body of the barge is about 168 ft. in length, the ends are alike and each, with long, easy rake of 42 ft., is molded for 66 ft. in length, with about 1 ft. sheer, and forms a spoon-shaped bow, giving remarkably easy lines and resultant least resistance to towing, yet the block coefficient of form was kept above 80 per cent, giving large displacement and capacity. The loaded economical speed is calculated at 5¼ m.p.h., and at this speed and 3½ ft. draft the resistance was found on trials to be only 1.7 lb. per ton of displacement (total weight of barges and cargo, 1200 tons), or fully one-third less than the resistance of standard short-rake, scow-bowed barges.

Owing to the great combined width of bottom (144 ft.) of a tow of three barges, with attendant heavy "drag" over shoal water, they are fitted with short wooden swinging side fenders in order to spread them slightly apart, thus offering spillways between the vessels, and for further relief, escape of drift, etc., the bilges are rounded with 5 ft. radius below the average draft line.

The barges are divided by 12 cross-bulkheads, and 1 central longitudinal bulkhead, or keelson, between bottom and hopper, into 2 fore peaks and 22 water- and oil-tight compartments, each controlled, as stated, by pipe lines and valves, vents, hatches, etc. Each barge when empty weighs about 550 tons, on 19½ in. draft, and the average cost at prevailing high prices is about $110,000 per barge.

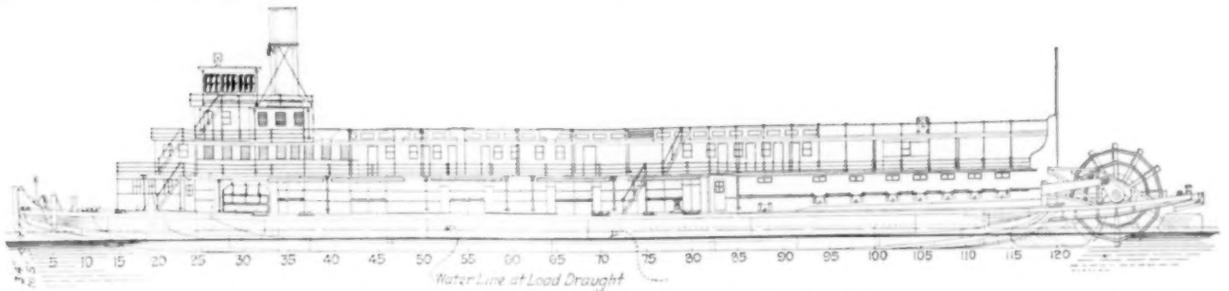
The barges have been constructed under separate contracts at three yards. They have been largely "fabricated" in the contractors' and associated shops, from templets taken from full-size mold lines, the fabricated parts being then erected on the launching ways. At this writing seventeen barges have been launched and completed, and the remaining two are expected to be finished in June.

Design and Construction of Towboats

The design of the towboats presented a problem even more complex than that of the barges. The power required to move a unit tow of three fully loaded barges, carrying 7500 tons of freight, upstream against the strong current of high water, is about 2000 hp., a greater power than has been heretofore provided (or developed) on a river towboat, yet the great weight of such a power installation, had to be mounted upon a hull of very light draft necessitated by the shallow depths at low water stages of the river. Nor can boats, as can barges, utilize fully in draft even the meager depths thus offered, but require, especially at the stern, a marginal or surplus depth below the hull to insure vitally essential backing power and maneuvering ability obtained by throwing the race water from the wheel under the hull. This requirement limited the low-water draft of the boat to slightly less than 4 ft. at the bow and about 3 ft. at the stern, but as these extreme conditions obtain only during the low-water season, with its greatly reduced currents and necessarily lighter loading of the barges, the full power of the wheel is not then required to be developed, and also the fuel supply to be carried may be greatly reduced, these conditions aiding to secure the lighter draft desired. At high stages the increased quantity of fuel to be carried, and possibly some water ballast in hull compartments provided therefor, can be relied upon to increase the draft 18 in. and 12 in., respectively, at bow and stern, and thus secure at will wheel immersion sufficient to develop the full power of the propelling machinery.

Three types of towboats and propelling wheels and appropriate machinery were considered; namely, hull with twin screw propellers in tunnels; side-wheel towboats; and the stern-paddle-wheel towboat of western river type, which was found to best fulfill the exacting conditions of the service planned. Objections to this type were the great overhanging weight of the paddle wheel, making difficult the fore-and-aft trim of the hull, and its rather inferior steering-ahead qualities as compared with side paddle wheels or twin screws; but its great backing and "flanking" (backing with strong sidewise movement) power give it unquestioned superiority over the other types.

The selection of the proper type of paddle wheel was also important. The radial fixed paddle wheel was chosen because of its simplicity of construction, ease of repair and, as compared to other types, light weight. The wheel designed probably will be one of the largest that has ever been installed in a stern-wheel towboat. While it weighs less than 60 tons, it will nevertheless



PROFILE, TOWBOAT FOR UPPER MISSISSIPPI RIVER.

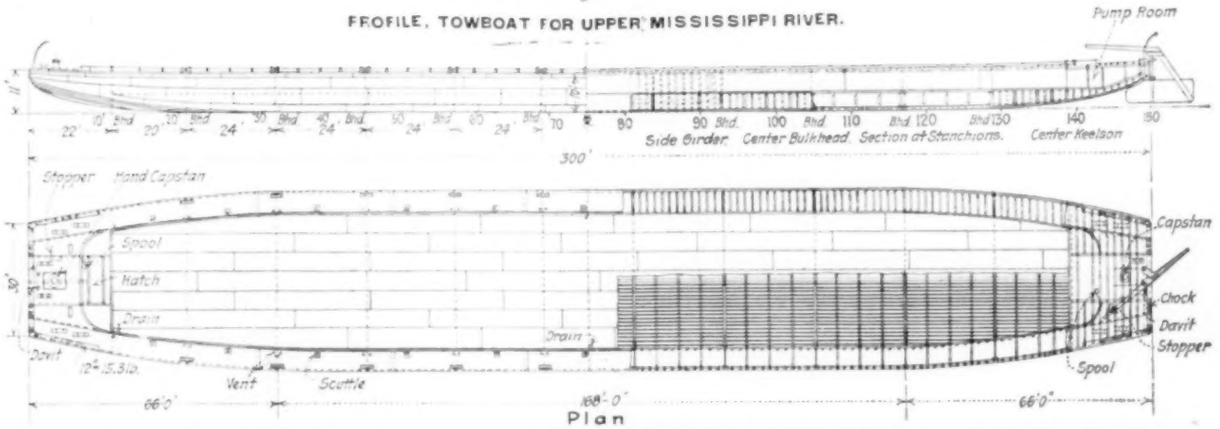


FIG.1.-GENERAL PLANS OF UPPER MISSISSIPPI RIVER OPEN HOPPER TYPE BARGE. LENGTH OF HOPPER, 256 FEET; WIDTH OF HOPPER, 36 FEET.

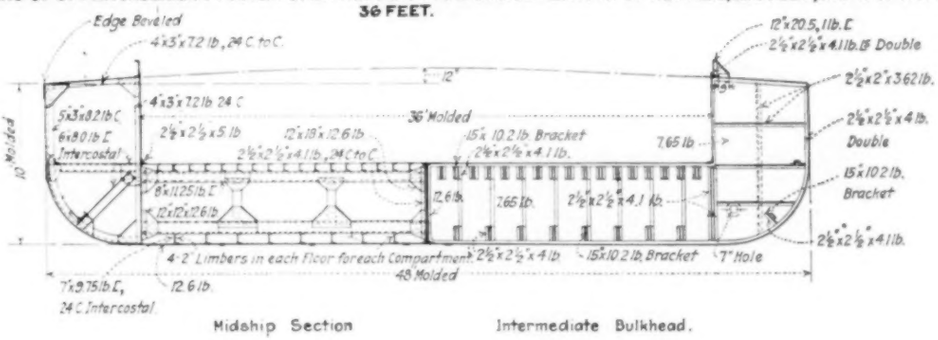


FIG.4.- MIDSHIP SECTION OF OPEN HOPPER TYPE BARGE FOR UPPER MISSISSIPPI RIVER

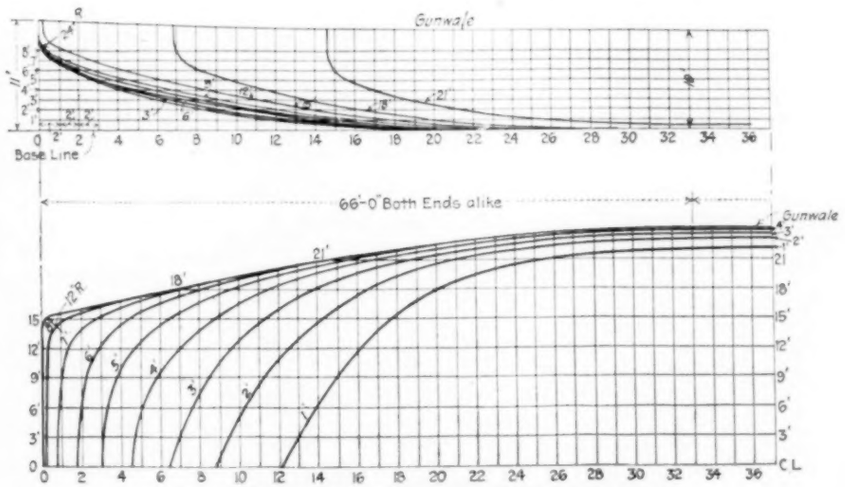


FIG.2.-MOLDED LINES OF UPPER MISSISSIPPI RIVER BARGE.

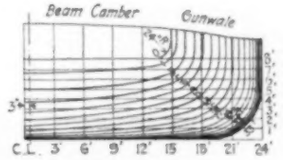


FIG.3.- BODY PLAN OF UPPER MISSISSIPPI RIVER BARGE.

be 22 ft. in diameter with 12 wooden paddles, each 40 ft. long by 3½ ft. wide, borne on 7 wheel flanges. The r.p.m. will be 22 to 25, to develop the full power of thrust of 50,000 lb. required. The shaft will be of forged nickel steel, carefully annealed and machined to dimensions. It will be 46 ft. 2 in. in length, 25 in. outside diameter, but with 7 octagonal seats on which the wheel flanges will be keyed, hollow-bored to 19 in. diameter, with the ends reinforced interiorly and integrally to 6 in. thickness under the crank grips and journals, tapering into 3-in. walls under and between the outside flanges.

The engines are twin tandem compound condensing, 24-in. high-pressure and 48-in. low-pressure cylinders, and 8 ft. stroke, and are designed for an initial pressure of 250 lb., with steam superheat of about 75 deg. In order to carry the great weight of the engines well forward of the stern of the boat, they are fitted with 2 sets of pitmen, crossheads and slides, separated by about 17 ft., an arrangement which has been tried recently with success on other government boats in the St. Louis District. The surface condenser is of usual type and has 3000 sq. ft. of cooling surface.

The boilers on each boat are two in number, of Heine cross-drum marine type, with 3½-in. tubes 14 ft. long; each boiler having 4250 sq. ft. of heating surface, 100 sq. ft. grate surface, and with stack superheater (Foster type) and feedwater economizer, fan blower leading directly above to an individual stack and with turbine forced draft in the furnace which is fitted with grates for coal fuel, but arranged also for ready installation of burners, air preheaters, etc., for oil fuel, as it is highly probable that tar fuel, which can be obtained from local coking plants, will be carried in the oil compartments in the hull.

The auxiliary machinery will include heavy steam capstans, hand capstans, settling tanks and neutralizing and clarifying plant for boiling water, domestic water supply, electric-lighting plant, refrigerating plant, steam steering engines and gear, oil and bilge pipe lines and the usual feed, fire and deck pumps, injectors for emergency boiler feed, coal-handling apparatus, machine tools for repairs, motor-boat tender for sounding, etc.

The hull will be fitted with a heavy steel spud and hoisting engine, as for a dredge, for anchoring the boat and tow and to afford a firm anchorage against which to pull to release barges grounded on the shoals, which so frequently happens in all shallow rivers.

Also, each boat is equipped with two sets of balanced rudders, one set of 4 rudders fitted, as usual, at the stern transom, forward of the wheel, and the other set of 2 rudders fitted aft of the wheel, each set acting alternately in the strong race water from the wheel when backing or going ahead, respectively, the double installation greatly increasing the steering and maneuvering power of the craft.

It was originally planned to install towing engines and tow barges behind the boat on cable hawsers as done in Europe, especially when running through narrow bridges, but on account of the expense of installation these engines were omitted, as were also the large rudders necessary for such towing. However, the foundations for the engines on the towboats and the rudder attachments on the barges were retained, and in future, if desired, the remainder of the required astern towing plant may be installed.

Each hull for all this machinery is 230 ft. long, 58 ft. beam and 8 ft. deep, and will displace about 1100 tons when under steam. As in the barges, so also in the boat hulls the sunken deck is used, forming a hopper 3 ft. deep from the boiler room nearly to the after transom, thus lowering the height of the deckhouses and reducing the wind surface of the boat, which will aid greatly in maneuvering heavy tows through the bridge spans, narrow channels and shoal water to be encountered. The deckhouses and accommodations also are of steel, and fireproof as far as is possible without undue weight.

A novel feature of the hull construction will be stiffening and strengthening trusses on each side running from the boilers to the wheel beams aft of the shaft, supporting the wheel and also supporting on the upper chords the entire steel middle deck (and superstructure), which thus incorporated into the top members of the trusses becomes an important component in the longitudinal strength of the boat.

Each boat will be completely outfitted for a full crew of 40 men, and will cost about $375,000 when complete, outfitted and turned over to the lessee.

Fabrication for all the boats is now well advanced and the erection of two hulls at Stillwater is progressing rapidly. It is expected that both will be in operation during the coming fall season, and that the remaining two will be ready by next spring.

Other River Fleets

As a reflex of this attempt to stimulate and revive commercial navigation on the upper Mississippi River, a similar movement was at once started to utilize the lower Mississippi River between St. Louis and New Orleans for general commercial transportation, and the United States Railroad Administration furnished funds to construct a fleet of 6 towboats and 40 large—2000-ton—barges, fitted with steel protective deckhouses, for that service, but without awaiting the construction of these vessels the Railroad Administration began operations in the summer of 1918 with a fleet of vessels obtained by purchase and lease from private and governmental owners. The new fleet is under construction, a number of the barges already have been delivered by the builders, and one of the towboats is soon to be in operation. The barges are of the scow-bow type and the boats are of the tunnel twin-screw type and about 1500-hp., that type being chosen for the boats as the low-water channel depths in the lower river are thought to be sufficient for such craft. It is expected that interesting comparison of the relative efficiencies of the two types of towboats and barges in the two river sections may be made after one or two years of operation.

The Great Warrior River also is to have a fleet of power barges now building as another of the sequelæ to the upper-river revival; and numerous inquiries from individuals and corporations indicate that many private barge and steamboat lines may be expected as the success of the Government lines becomes apparent.

Terminal Facilities

As a result of widespread and searching public discussion and of investigations by the War Department, covering the entire field of transportation, it was early seen that modern, up-to-date docks and terminal facilities, warehouses and yard trackage, all equipped and arranged for convenient, quick and economical interchange of freight between water and rail carriers, are essentially, almost vitally, necessary adjuncts to successful and effective use of the rivers.

In promotion of such facilities a circular letter was issued in October 1917 by the Board of Engineers for Rivers and Harbors (advisory to the Rivers and Harbors Committee of the House of Representatives in Congress), which was distributed by the War Department to all municipalities concerned, calling upon cities and towns located on navigable streams to construct and maintain proper river terminals, open to all on equal terms, as a prerequisite to further appropriations for river improvement, and in encouragement of a revival of river-borne traffic. In response thereto the cities on the Mississippi River and its tributaries, generally speaking, have made earnest efforts to comply by planning and arranging for terminals and wharves to such extent that every important city on the river between St. Louis and Minneapolis, and on the Illinois River, has either built terminals or has prepared financially to do so, as necessity therefor arises. Particulars of these developments are given in the complete paper. This indicates an intense public interest in the question of river traffic, as, practically, commercial navigation on these rivers is now at its lowest ebb.

In the foregoing sketch of that part of the present active effort to revive water transportation, possibly centering at St. Louis and on the Mississippi River, may be seen the very general public interest in the use of the river, and it is hoped that the seed sown by the Government in its aid to the movement may have fallen on fertile ground and will return the economic relief and harvest for which the Mississippi Valley has hoped so long.

Superchargers for Airplane Engines

The Necessity for Supplying Air to the Carbureter at Sea-Level Pressure at High Altitudes—The Moss Supercharger for This Purpose, Its Design, Development and Performance

By SANFORD A. MOSS,[2] WEST LYNN, MASS.

AN airplane flying at high altitude is in an atmosphere of comparatively low density. For instance, at 20,000 ft. altitude the density is practically half that at sea level. This means that a given volume contains half as much actual air by weight. The cylinders of an airplane engine are therefore charged with an explosive mixture which has about half the value of a charge at sea level. The engine actually delivers about half of its sea-level power at 20,000 ft.

Both the low temperature and the decreased pressure at high altitude have effect in fixing the high-altitude density. Both the decrease of temperature and the decrease of weight of the charge affect the carburation at high altitude. The fixed clearance volume and the decreased initial pressure give a decrease of compression pressure resulting in a loss of efficiency. There is, therefore, a combination of causes which gives as a net result a decrease in engine power very nearly proportional to the decrease in density.

At high altitude the resistance of the air to the motion of the airplane is decreased directly in proportion to the decrease of density. The power required for a given airplane speed is therefore greatly reduced. However, the engine power has been so reduced that the usual net result is a considerable decrease in airplane speed. When the engine power is maintained at the sea-level value, there is, however, a considerable increase of speed at high altitude.

Filling the cylinders of an internal-combustion engine with a charge greater than that which would normally occur, is called "supercharging." Methods of doing this have engaged the attention of a great many experimenters.

The centrifugal compressor is an apparatus similar to the fan blower except that the shape of the impeller blades and the passages leading air to and from the impeller are so arranged as to give an efficiency very much greater than that of the usual type of fan blower, so that the apparatus forms a satisfactory means for compressing air to appreciable pressures. A line of single-stage centrifugal compressors has been developed for compressing air from 2 to 5 lb. per sq. in. above atmosphere, to be used for many industrial purposes; as well as a line of multi-stage machines for compressing air and gas up to pressures of 30 lb. per sq. in. above atmosphere.

The turbo-supercharger is a combination of a gas turbine and a centrifugal compressor, arranged as part of an airplane gasoline engine. The hot products of combustion from the engine exhaust are received upon the turbine runner and furnish power whereby is driven a centrifugal compressor mounted on the same shaft, which compresses air for supply to the carburetors. A more detailed description is given later, as well as particulars regarding its development.

In the latter part of 1917 the National Advisory Committee for Aeronautics requested the coöperation of the General Electric Company in the development of the turbo-supercharger in the United States. Our work was originally started at the suggestion of Dr. W. F. Durand, then Chairman of the Committee, who knew of our long experience with gas turbines and centrifugal compressors. It has since been carried on under the supervision at various times of Col. J. G. Vincent, Col. T. H. Bane, Major H. C. Marmon, Major G. E. A. Hallett and Major R. W. Schroeder. Major Hallett has had charge of the development since the armistice, and he has given considerable study to the matter of superchargers in general.

[1] Condensed from an article on The General Electric Turbo-Supercharger for Airplanes, published in the June 1920 issue of the *General Electric Review*, to which journal MECHANICAL ENGINEERING is indebted for advance proofs of the article and for the illustrations here used.

[2] Engineer, Turbine Research Department, General Electric Co. Mem. Am.Soc.M.E.

THE TURBO-SUPERCHARGER CYCLE

Fig. 1 shows an airplane engine equipped with a turbo-supercharger. The exhaust of the engine is received by an exhaust manifold which leads it to a nozzle chamber carrying nozzles which discharge it on to the buckets of a turbine wheel. On the same shaft as this turbine wheel is the impeller of a centrifugal compressor. This compresses air from the low-pressure atmosphere to approximately normal sea-level pressure and delivers it to an air-discharge conduit which supplies the carburetors.

The turbine nozzles are of such area as to maintain within the exhaust manifold and nozzle box a pressure approximately equal to that at sea level. The difference between this pressure and the altitude low pressure gives a pressure drop for the exhaust gases which furnishes the power that operates the system.

Due to the respective temperatures this power input suffices to

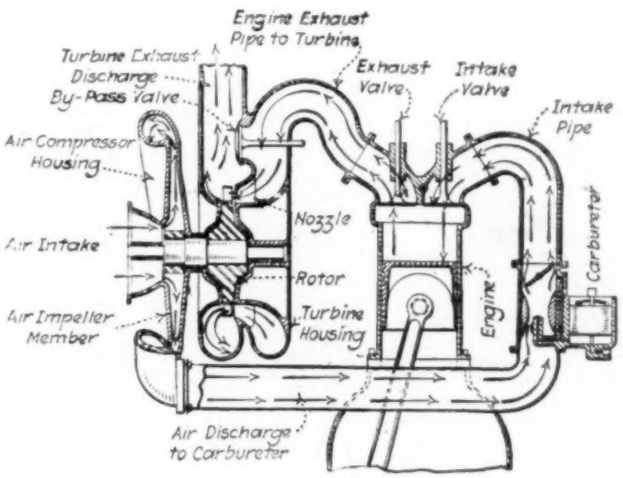


FIG. 1 DIAGRAMMATIC SKETCH OF AN AIRPLANE ENGINE EQUIPPED WITH A SUPERCHARGER

give the desired compression and also to supply the inevitable losses. However, in order to avoid back pressure on the engine, above the normal sea-level value, both turbine and compressor must be designed with utmost attention to efficiency.

With an efficient arrangement the engine when at high altitude exhausts at normal sea-level pressure and receives its air at the carburetor at normal sea-level pressure. Hence, normal sea-level power is delivered at all altitudes up to the maximum for which the supercharger is designed, so that the plane speed will increase uniformly as the altitude density decreases.

MECHANICAL PROBLEMS OF SUPERCHARGING

The General Electric superchargers thus far constructed have been designed to give sea-level absolute pressure at an altitude of 18,000 ft., which requires a compressor that doubles the absolute pressure of the air. This pressure ratio, with the quantity of air involved, means about 50 shaft hp. input for the compressor. The design of a complete power plant of this size to suit an existing airplane engine, with such weight and location as will not impair the flying characteristics of the plane, has of course offered many problems. The possibility of driving the compressor of the supercharger by engine power instead of by the exhaust gases suggested itself. Much experience with the operation of the gas turbine, however, led the writer to prefer its problems to those of the driving mechanism of a supercharger operated from the engine. The turbine involves merely the addition to the compressor of a single extra wheel, designed for the conditions, with

no extra bearings. The engine-driven scheme involves a 50-hp. transmission with a multiplicity of gears, bearings, clutches, belts, and the like. These offer more or less drag on the engine when the supercharger is not in use at low altitudes, and very serious problems of acceleration when the supercharger is to be thrown into action, since the engine will be then running at its full speed of about 1800 r.p.m.

The exhaust manifold and nozzle box have proved to be a very efficient exhaust muffler and conductor. Such a muffler and conductor is needed in any event, and the design of means for withstanding the increased pressure difference of the turbo-supercharger has been successfully accomplished.

Power for Turbo- and Engine-Driven Superchargers

An efficient turbo-supercharger theoretically deducts from the indicated horsepower of the airplane engine an amount corresponding to the difference between sea-level absolute pressure and altitude pressure. There is this additional back pressure during the exhaust stroke. The theoretical power available for driving the turbo-supercharger is greater than this, however, owing to the fact that there is available not only the energy due to the direct pressure difference mentioned, but also the energy of perfect expansion from the higher to the lower pressure. If there were no turbo-supercharger the engine would waste this energy in sudden pressure drop as the exhaust valve opens. The turbine can utilize this energy. The sum of these two amounts of available energy, multiplied by the efficiency of the turbine wheel, gives the shaft power delivered to the compressor.

For an engine-driven supercharger compressor there is greater engine indicated power due to a lower exhaust pressure. However, the shaft power for the supercharger compressor must be transmitted through the engine connecting rod and crankshaft, with losses, and then through the supercharger driving mechanism with additional losses. The total shaft power thus subtracted from the engine, multiplied by the efficiencies of these two transmissions, gives the shaft power delivered to the compressor. This is the same as for the turbo-supercharger. For a Liberty motor of about 400 hp. and sea-level power at 18,000 ft. altitude, this power is 50 hp.

The comparison then is as follows: The turbo-supercharger subtracts from the engine indicated power, adds power of expansion which would not otherwise be used, and has turbine wheel losses. The engine-driven supercharger puts this indicated power through the engine (with some additional loads on the pins and bearings) and has engine and transmission losses.

With usual efficiency there is probably not a great difference between the gross subtraction from engine power in the two cases. There is then the disadvantage of transmitting the supercharger power through the engine pins and bearings, as well as through some mechanism between engine and supercharger, to be compared with the collection of the hot gases under pressure (with muffling advantages) and delivery to the turbine wheel. As already mentioned, practical success to date is in favor of the turbo-supercharger and the writer feels that this is really due to its innate superiority.

Engine-driven superchargers with positive-pressure blowers have been proposed. These have the additional disadvantage that with the desirable pressure ratios of about two to one there is an appreciable compression loss due to the fact that the machine only displaces air and has no direct means for compression.

Supercharging engines of various kinds, in which the engine crankcase or the engine cylinders themselves are arranged for additional compression, have been shown to give excessive weight and complication as compared with a turbo-supercharger.

Development of the Turbo-Supercharger

The machines used thus far have been designed to give sea-level pressure at 18,000 ft. altitude, which corresponds to a pressure ratio of about two. The rated speed for these conditions is 20,000 r.p.m. Sea-level pressure has readily been obtained up to 22,000 ft. altitude. The control is entirely by hand operation of waste gates, which permits of free escape of some of the exhaust gases.

The entire apparatus, exclusive of exhaust manifold and air-discharge conduit, weighs about 100 lb. The exhaust manifold and air conduits have nearly the same weight as equivalent parts with no supercharger.

The turbine and compressor wheel have diameters somewhat less than a foot. The present design has been hampered by necessity for accommodation to existing engines and planes. It is proposed, however, to construct apparatus in which engine and supercharger are integral, with all parts arranged for the full possibilities of the combination.

In the combination under consideration the airplane, propeller, engine, radiator, cooling system, and supercharger are so intimately associated that no adequate tests can be made without the complete system in operation at full speed at altitude. During the initial development of the Liberty motor a testing expedition had been sent to the summit of Pike's Peak, and it was decided to repeat this performance with the supercharger. Fig. 2 shows the motor truck that was prepared for the expedition and Fig. 3 the way it was left after each day's work. The Liberty motor carrying the supercharger was mounted on a cradle dynamometer, with scales and all arrangements for accurate measurement of power, gasoline consumption and the like. In fact, a complete testing laboratory was provided. The motor truck was shipped by rail to Colorado Springs, and then proceeded by its own power to Pike's Peak summit on the "Pike's Peak Auto Highway," a well-constructed but very tortuous mountain road 28 miles long. The summit has an altitude of 14,109 ft. and it is the highest point in the United States easily reached by road.

The testing work at the summit lasted through September and half of October, 1918. The usual difficulties with experimental

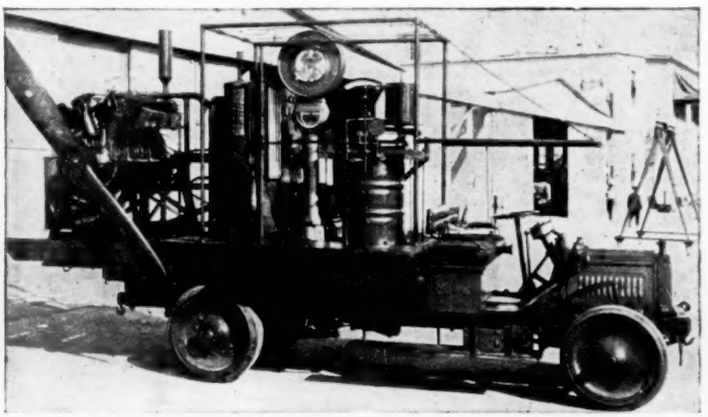


Fig. 2 Motor Truck Prepared for Expedition to Summit of Pike's Peak for Testing Liberty Motors

Fig. 3 Showing Way in Which Motor Truck of Fig. 2 Was Left After End of Day's Work

work were, of course, encountered with the addition of many delays, due to the cold and snow, and distance from repair shops. The apparatus was finally arranged to give good mechanical operation and it was found possible at the existing altitude of 14,000 ft. not only to supercharge so as to give full sea-level power, but also to overcharge so as to cause the engine to preignite.

It was agreed that results of the tests warranted the immediate installation of the supercharger on an airplane, and arrangements for doing this were in progress when the armistice caused a cessation of the work. After the armistice, careful reëxamination of the situation resulted in resumption of the work in the early part of 1919. Various rearrangements were made in view of the experience gained at Pike's Peak and the apparatus was finally installed on an airplane.

It soon developed that a very appreciable increase of power was easily obtained when the supercharger was opened up. The whole airplane installation was not properly arranged to take advantage of this power, however, and changes were necessary in the radiator, cooling system, propeller system, gasoline tank,

FIG. 4 RIGHT TO LEFT: MAJOR R. W. SCHROEDER, LIEUT. GEO. W. ELSEY AND DR. MOSS

pump system, etc. Changes in these parts have been made from time to time, and this work is still in progress. As the work proceeds more and more power is developed by the engine. Changes have also been made in the supercharger itself.

Fig. 4 shows Major R. W. Schroeder, who has made all of the flight tests to date, together with Lieut. George W. Elsey, who has made all of the flight observations to date. The aviators are of course clothed for the intense cold of high altitudes and carry the parachutes that are now regularly used by the U. S. Air Service in experimental work.

SUPERCHARGER PERFORMANCES

The supercharger which has been used to date was primarily desired for high speeds at altitudes of 18,000 to 22,000 ft. The Le Pere plane on which the installation was made had a ceiling of about 20,000 ft. with two men, and a speed at this altitude of 70 miles per hour. With the supercharger in use, a speed of about 140 miles an hour has been attained at 22,000 ft. As already pointed out, this has been attained with various parts of the plane installation in a partially developed state. Theoretical computations have been made showing that much higher speeds at high altitudes are to be expected, and the flight tests to date indicate that the theoretical expectations will be fully realized.

The making of high altitude records has been very attractive and the supercharger has, of course, been used for this purpose as well as for the speed courses mentioned. Successively higher altitudes have been reached as experience has been gained regarding the manipulation of oxygen, gasoline, and other details.

On February 27 Major Schroeder made a flight alone, attaining an actual height above the ground finally computed as 36,130 ft. (6.85 miles). The lowest temperature reached was minus 67 deg. fahr. At the maximum altitude his oxygen apparatus failed and he became unconscious and lost control of the plane, which fell almost vertically. As he neared the earth he partly recovered consciousness and, at an altitude of about 3000 ft., succeeded, in a half-dazed semi-automatic way, in righting the plane and making a good landing in his own field, again becoming unconscious. He was taken to a hospital in a serious condition, but has since almost completely recovered. The supercharger, engine, and plane were in perfect working order after the flight.

At the maximum altitude attained, recording instruments showed that the plane was still climbing at the rate of about 125 ft. per minute and it was estimated that an altitude of 40,000 ft. would have been attained if the oxygen apparatus had not failed.

[In the May issue of the *General Electric Review* there also appears a reprint of a paper on Superchargers and Supercharging Engines, by Major George E. A. Hallett, U. S. A., presented at the annual meeting of the Society of Automotive Engineers, January 7 and 8, 1920. Major Hallett, who is Chief of Power-Plant Division, U. S. Air Service, deals at some length with the various methods employed in supercharging and refers to the work of the U. S. Air Service on the Rateau type of turbo-compressor, under the supervision of Mr. E. H. Sherbondy, prior to that undertaken by Dr. Moss. Commenting on the working of the Moss supercharger, he says:

> It would naturally seem at first thought that the extremely low temperatures always found at great altitudes would make possible the easy solution of cooling problems, but in reality the low density of the air reduces its heat conductivity and capacity for heat absorption to such a point that a supercharged engine developing sea-level power at 20,000 ft. requires a little *more cooling surface* than it does when developing normal power at sea level.
>
> The Liberty engine and many others run best with a water temperature of about 170 deg. fahr. To maintain the cooling water at this temperature in the reduced atmospheric pressure at 25,000 ft. it is necessary to use several pounds of air pressure in the radiator to prevent the water from boiling away. Very effective radiator shutters are needed when the engine is throttled to make a descent from altitudes of over 20,000 ft. to prevent the water in the radiator from freezing before warmer air is reached.
>
> Contrary to expectations, the Moss turbo-compressor now being tested at McCook Field does not complicate the pilot's controls. On a normal engine the pilot handles the throttle and the altitude carburetor control which thins down the mixture as he ascends. With the turbo-compressor the altitude control becomes unnecessary up to the altitude at which the engine can no longer deliver sea-level power but is used, as with a normal engine, if the plane is driven higher.

As to the future of the supercharger, Major Hallett says:

> The uses of the supercharger for military service can be divided into: first, for airplanes in which it is desired to reach extreme altitude; second, for airplanes in which it is desired to increase the rate of climb and horizontal speed and therefore maneuverability at altitudes where it is intended to fight; and, third, for airplanes which carry large loads such as bombers, which normally are handicapped by having a very low ceiling and whose entire usefulness would, if larger engines were installed to pull them to a higher ceiling, be lost on account of the large amount of fuel and other material that would have to be carried, thus decreasing their radii of action.
>
> In the first case it is believed that a special supercharger can be built that will make feasible much greater altitudes than any that have been attained with the present General Electric turbo-compressor; and it is considered essential that we have airplanes capable of reaching very great heights. In the second case, it is pointed out that military machines not fitted with supercharging engines, when fighting at an altitude of 20,000 ft. or more, are so near their ceiling that their rate of climb, speed, and maneuverability are comparatively poor, but the use of a supercharger seems to overcome this difficulty easily.
>
> The use of superchargers in commercial airplanes of the future is assured because superchargers will make possible far *more miles per hour* and *more miles per gallon* with a given engine and airplane, and speed is the main advantage of air over other kinds of transportation. It is thought by many qualified judges that by flying at a sufficient height with a supercharged engine and a suitably designed airplane, a speed of 200 m.p.h. can be maintained.]

Spring Meeting of The American

Whole-Hearted Hospitality Extended by St. Louis — Engineers Present From Many Sections Professional Sections Started — Discussion of Local Engineering Problems Joint Session With Society of Refrigerating Engineers

THE 1920 Spring Meeting was the first convention of the Society to be held in St. Louis in twenty-four years and so open-hearted was the hospitality, so well carried out were the excursions and entertainments, and so thoughtfully was every detail worked out for the comfort of the guests that every member in attendance enthusiastically demanded an early repetition of a St. Louis Spring Meeting. It was successful in every phase, as in addition to the social features the professional sessions were well attended and pertinent discussions contributed.

The meeting gained momentum quickly, the business session starting promptly at 2 p.m. on Monday, being followed by the professional sessions as scheduled. The total registration was 475 members and 330 guests, most of whom arrived for the first session and remained to the end. All of the professional sessions were held at the Hotel Statler, the headquarters of the meeting.

Opening Reception

On Monday evening a reception for visiting members was held in the Hotel Statler. Clarence H. Howard, president of the Commonwealth Steel Company of St. Louis, extended a warm welcome and spoke about the development of the Junior Chamber of Commerce and the importance of business training for young men and boys. President Miller responded with the thanks of the Society for the hospitality shown up to that time and anticipated during the remainder of the convention. He also spoke of the problems in industry and earnestly pleaded for closer co-operation between workmen and managers. Mr. E. R. Jackson displayed several reels of the official moving-picture record of the First Transcontinental Motor Convoy. The pictures were accompanied by comments from Mr. Jackson on the various events taking place on the trip, and were received with interest and close attention. Mr. L. C. Nordmeyer, chairman of the St. Louis Section, presided at this meeting. The members of the St. Louis Section proved delightful hosts and everyone thoroughly enjoyed the dancing which followed.

Entertainment

The Spring Meeting banquet, held Tuesday evening, May 25, in the large dining room of the Missouri Athletic Association, was attended by over 700 members and guests. A fine musical program was presented during the dinner, after which Lt.-Col. H. W. Miller, of the Ordnance Department, presented a paper on the German Defenses on the Coast of Belgium. Colonel Miller's paper, which appeared in the June MECHANICAL ENGINEERING, is a valuable contribution to the information necessary for the solution of the coast-defense problem of this country. The very formidable fortifications thrown up by the Germans on the coast of Belgium kept the Allied fleets at bay for three years and the lessons that may be learned from this paper are of great interest to every one who understands the great problem before the War College in the selection of proper methods of coast defense.

A special entertainment for all engineering societies holding meetings in St. Louis and all members of St. Louis engineering societies was arranged at the beautiful new municipal open-air theater in Forest Park. The interesting program of music and interpretative dancing was presented from a picturesque natural stage, which, viewed from the outer circle of the amphitheater, gave an inspiring perspective of lights and color. St. Louis may well be proud of this concrete structure, holding 7000 people and having perfect appointments.

On Thursday afternoon the excursion steamer *St. Paul* was chartered for a boat ride up the Mississippi. This trip was a decided success in that it afforded a fine opportunity for making acquaintances and for that reason was voted the most successful entertainment of the meeting. Music and dancing were enjoyed on the boat.

The ladies attending the convention were particularly well taken care of and were afforded very interesting trips through the residential section, through Forest Park and visits to the Art Museum, Shaw's Garden, Washington University and to Brentmoor, Westmoreland and Portland Places.

Trips of Inspection

The trips of inspection planned by the St. Louis Committee covered a wide variety of industries and engineering works for the visiting members. On Tuesday afternoon the plant of the Commonwealth Steel Company at Granite City, Ill., was visited by a large number who were very much interested in the new methods shown for making steel castings. The 122,000-kw. plant of the Union Electric Light and Power Company at Ashley Street was also visited Tuesday afternoon, followed by a call at the docks of the St. Louis Boat and Engineering Company where steel barges are under construction for the United States Government.

Wednesday morning the trips included the plants of the General Motors Corporation, Wagner Electric Company, Evertight Piston Ring Company, and Heine Safety Boiler Company.

Society of Mechanical Engineers

of the Country — Members Enthusiastic and Meeting Pronounced a Great Success — Two Important Feature — Appraisal and Valuation Session Excites Interest — and Society of Heating and Ventilating Engineers.

Lunch was served at the Bevo Plant of the Anheuser-Busch Association, following which the party moved on to the works of the Busch-Sulzer Brothers Diesel Engine Company, the Mississippi Valley Iron Company, and the coke plant of the Laclede Gas Light Company.

Public Hearings

On Tuesday morning, May 25, at 10 a.m., the Committee on Protection of Industrial Workers opened to public discussion the Elevator Code covering the construction, operation and maintenance of elevators, dumbwaiters and escalators. Many useful criticisms and suggestions were advanced which will be considered in the work of the Committee. At 2 p.m. on Tuesday the Boiler Code Committee held a public hearing on the Rules for Air Tanks and Pressure Vessels. At this session the discussion centered largely on the value of welding the seams of the vessels under consideration.

Keokuk Excursion

Eighty members of the Society availed themselves of the opportunity to inspect the hydroelectric developments of the Mississippi River Power Company at Keokuk. The special cars arrived at Keokuk Sunday morning and were met by representatives of the Power Company and after an Iowa breakfast the party was split up into small sections which were effectively guided across the locks and docks to the power house and dam. Every detail was explained carefully and with consideration by the power-house attendants. Mr. L. E. Dickinson was in charge of the plant for the day and to his courtesy and thoughtfulness the success of the excursion was undoubtedly due. After the power-house inspection the party motored about the adjoining country and after dinner went aboard the sleeping cars and arrived at St. Louis on Monday morning.

Tulsa Trips

Following the meeting in St. Louis, about fifty of the attending members left for Tulsa, where, Friday and Saturday, a joint meeting of the Mid-Continent section of The American Society of Mechanical Engineers was held with the Oklahoma section of the American Chemical Society. A full account of this meeting and the trips in connection with it is given elsewhere in this issue.

Local Committees

The entire arrangement for the entertainments, excursions and publicity for this meeting was under the jurisdiction of the General Committee, the personnel of which was as follows: M. L. Holman, Hon. Chairman; Louis C. Nordmeyer, Chairman; Lewis Gustafson, Vice-Chairman; Fred. E. Bausch, Secretary; William P. Samuel, Treasurer; Ernest L. Ohle, H. Wade Hibbard, Chester B. Lord, Edward W. Schadek, Victor J. Azbe, and Edward R. Fish.

Emphasis must again be placed on the hospitality extended by the St. Louis Section and the thoughtfulness with which every detail was worked out. The work of the Women's Committee, of which Mrs. Ernest L. Ohle was chairman, in anticipating every desire of the wives of the visiting members and guests was particularly noteworthy.

In the publicity work the St. Louis Convention and Publicity Bureau was very helpful and its representative, Mr. Francis E. Turin, worked in very close coöperation with the Committee.

Business Meeting

THE matters coming before the business meetings of professional societies are often regarded by the members as uninteresting. However, at the semi-annual business meeting in St. Louis, held on the Monday afternoon, the attendance was quite large and the discussion general, indicating a good interest in the various details presented for consideration.

Vice-President Fred R. Low opened the meeting, and after a few minutes President Miller took the chair and introduced the subjects of the meeting.

The first business presented by the Secretary was the report of the Tellers of Election, John H. Lawrence, Manelus S. Hutton and R. K. MacMaster, on amendments to the Constitution. This report was adopted on the motion of Mr. Low and the amendments declared carried. They provided for

a Addition of Standing Committee on Professional Sections.

b Approval or adoption of reports, standard formulæ or recommended practices.

c Termination of membership on the Council or any committee on account of absence.

The amendments were published in Mechanical Engineering, January, 1920, p. 33.

Mr. H. J. C. Hinchey then presented the report of the Special Committee on Code of Ethics. This report with the Code incorporated in it will be published in Mechanical Engineering. The report was referred to Engineering Council or to such organization as may be formed for joint action by the Engineering Societies on matters of common interest to form the basis of a

possible general Code of Ethics. The Committee was continued to take such action as might seem advisable looking toward the adoption of a Code by the Society in case no other suitable action was taken.

A report of the Boiler Code Committee on Boilers for Locomotives was presented by title and those interested were referred to a special session held for its discussion.

Under new business President Miller introduced an amendment to the Constitution shortening the time required to complete amendments to the Constitution, which was discussed but no modification made. This amendment will follow the usual procedure.

The question of coöperation by the Society with the National Public Works Department Association was introduced and discussed, and the next day the following resolution was passed indorsing this movement:

WHEREAS: The American Society of Mechanical Engineers believes thoroughly in the principles of functional organizations and its members, as engineers, are particularly concerned with reorganizations leading to the substitution of efficiency and economy for looseness and waste, therefore, be it

Resolved: That The American Society of Mechanical Engineers in convention assembled fully indorses the effort which the National Public Works Department Association is making to achieve these results and specifically urges upon its local sections that in conjunction with the Local Engineering Societies these sections support this movement fully and effectively.

Mr. Morris L. Cooke introduced an amendment to the Constitution to extend the privilege of voting to Junior Members. He cited a resolution passed by the Philadelphia Section making such a recommendation. He quoted figures to show that the Junior Membership was approximately 23 per cent of the total and that that part of it below the age of twenty-seven was only 8 per cent.

Mr. Cooke also spoke of the necessity of affording proper outlet for the ideas and activities of the younger members and stated that the required combination consists of the sagacity and experience of the older men and all that young men give. Mr. Cooke's analysis of Junior Membership is shown in the above table.

The proposal was discussed by S. N. Castle, M. M. Case, H. B. Dirks, Max Toltz, C. B. Lord, J. H. Bernhard and J. M. Spitzglass, and Mr. Cooke's proposal was accepted by the meeting and his amendment will therefore go through the usual procedure.

At the adjournment of the business meeting the session on Appraisal and Valuation convened immediately.

Two Professional Sections Started

WELL-ATTENDED conferences looking to the organization of Machine Shop Practice and of Power Professional Sections under the new authority of the Council were held at the Spring Meeting, and at both of them the sentiment toward the organization of the sections was unanimous.

The Machine Shop Practice conference was held on the Monday morning and was called to order by Prof. H. P. Fairfield who was the Secretary of the former Sub-committee of the Meetings Committee on this subject.

The meeting instructed Professor Fairfield to appoint a committee of three to proceed with the organization of the section, and he selected R. E. Flanders, C. B. Lord and himself. The Committee met immediately and decided on a form of petition to the Council and reconvened the general session on the Wednesday when signatures to the petition were taken.

On the Monday the Council voted to refer this petition when received by the Secretary to the Executive Committee of the Council for action.

The conference on the Power Section was held on the Wednesday morning when Prof. R. H. Fernald, member of the Special Committee on Professional Sections representing this subject, called the meeting to order.

Practically the same procedure was followed as in the meeting of the Machine Shop Practice Section and Professor Fernald appointed F. R. Low, J. R. Bibbins, and A. L. Rice as the Organization Committee. This Committee drew up the petition and it has already been received by the Secretary and is being balloted on by the Executive Committee of the Council.

To date 350 members of the Society have registered in the new Machine Shop Practice Section and 850 members in the Power Section. Both of these Sections expect to conduct sessions at the forthcoming Annual Meeting under the auspices of the Committee on Meetings and Program.

During the discussion at these conferences it transpired that there was a little doubt as to the difference between a professional section and a professional session of a general meeting. The Professional Sections are intended to be organizations of a per-

AGE AT WHICH ELECTED TO MEMBERSHIP

PRESENT AGE, 1920	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	Total	Per Cent
21	15																													15	0.5
22	33	26																												59	2.0
23	19	44	46																											109	3.7
24	20	37	70	38																										165	5.6
25	32	42	55	92	39																									260	9.0
26	11	38	72	69	83	50																								323	11.1
27	3	22	50	81	62	79	26																							330	11.2
28	6	12	28	40	84	73	50	5																						292	10.2
29	1	13	39	42	45	62	47	41	12																					306	10.6
30		3	16	35	40	52	54	26	34	9																				270	9.4
31	1	1	6	21	30	28	43	27	16	6	1																			180	6.2
32	3		4	10	16	23	19	18	25	4	11	3																		136	4.7
33		3	4	6	12	11	22	7	24			3																		93	3.1
34		3	3	5	5	10	11	20	8	1	1	1	6	4																78	2.7
35		2	2	5	2	3	9	13	20			1	2	3																62	2.1
36		2	2	4	4	5	1	8	7	1		1	2	3	1	2	1													44	1.5
37	2	1		4	5	5	6	5	4	2	1					1														36	1.2
38	1	2	2	1	2	3	2	3	3								2													20	0.7
39	1	1	2	1	1	4	1	3	1							1														16	0.5
40					2	5	2	1			1						2													13	0.4
41	1					1	4	1		1																				8	0.2
42			1	1					1		1	1																		5	0.1
43					1	2	1	1	1		1																			7	0.2
44		1		2	1		1		1				1											1						8	0.2
45						2	1	2		1	2	2													1					11	0.3
46						1	1	1		2	1		1										1			1				8	0.2
47						2	1	1		1		1		1													1			6	0.2
48			1		1																					1				2	0.1
49	1	1	1			1	2	1																				1		7	0.2
50																													1	1	
51					1		1			1																				3	0.1
52																															
53					1		2								1			1												5	0.1
54		1							1							1		1												4	0.1
55							1																							1	
56																															
57																															
58																															
59																															
60																															
61																															
62															1															1	
Total	150	255	404	457	441	423	309	184	158	29	20	13	14	11	3	5	3	2						1	1	2	1		1	2687	
Per Cent	5.2	8.8	14.0	15.9	15.2	14.8	10.4	6.4	5.5	1.0	0.7	0.4	0.4	0.3	0.1	0.1	0.1														100

STATISTICAL ANALYSIS OF AGE DISTRIBUTION

JUNIOR MEMBERS

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

MAY 1, 1920.

	Arithmetic Average Age	Median Age	Modal Age
With respect to age at which elected to membership	25.1	26.4	25.0
With respect to present age	28.8	27.6	27.5

(Number of college or technical school graduates 2184 or 75.3 per cent)

Age not indicated 15
Total examined 2902

ANALYSIS OF JUNIOR MEMBERSHIP PRESENTED BY MR. M. L. COOKE AT THE BUSINESS MEETING

manent character of groups of members of the Society who will devote continuous attention to their development of their subjects and will report either at Annual Meetings or at Local Section meetings or at meetings of their own or through the publications of the Society. Professional sessions at general meetings are simply divisions of the program of the professional papers presented to the Society determined upon by the Committee on Meetings and Program for convenience in conducting the Annual and Spring Meetings; the names of these sessions depending on the character of the papers on hand and the topics selected by the Meetings and Program Committee for the conventions.

Advantages of Professional Sections Brought Out

The organization of Professional Sections is a new one and it might be well to quote some of the views of the members expressed at the Spring Meeting on the development of the Society's work into this channel. Here are some of the opinions:

There is great value in what we sometimes call "verandah talks" in little groups with no reporter present, and so long as we keep within the limits of the Society's activities prescribed by the Council, I see no harm in these.

The Professional Sections will give the particular phases of engineering to which they are devoted more standing and dignity than was possible under the old arrangement of Sub-committees of the Meetings Committee.

There are two tendencies in the Society: One is to narrow everything down to the purely technical, and the other is to open everything out to include general things of interest. The more we force ourselves into the narrow technical side of engineering the less good we will be to the community and the less influence we will have.

This Professional Section movement is a very important one in the life of the Society, but we must guard against duplication of effort which will have a tendency to weaken what is destined to become a very important development.

In the Professional Sections so far we are simply limited by the matter of expense. When that is overcome we shall have a perfectly free hand as to presenting papers and holding sessions at any time and anywhere in the country, with the restriction that if we desire sessions in the regular Annual and Spring Meetings, we must come on the regular program prepared by the Meetings Committee and do things under their instructions.

The general idea prevails throughout the country that in order to get into The American Society of Mechanical Engineers one must possess a M. E. diploma or be a college graduate. This is not the actual requirement, but nevertheless the qualifications for membership are high. One object of the Professional Sections is to interest a number of men in the work who are not immediately eligible for membership in the Society, but who can join these Sections as Affiliates.

There are a great many men in the country who know all about every phase of the work of the various Professional Sections being organized, but there are no organizations in their particular little fields which interest them. These men should be brought into our organization.

Appraisal and Valuation Session

THE five papers submitted for this session had been previously contributed as discussion at the 1919 Annual Meeting and because of lack of time for complete consideration, it was decided to present the papers again at the Spring Meeting in 1920. The wisdom of this action was apparent from the interest shown and the value of discussion advanced. No agreement was reached as to methods of valuation and because of the grave importance of the subject to the engineering profession, resolutions were passed at the close of the Session which will keep the subject a vital issue before the Society.

This session, presided over by Dean Charles Russ Richards, Manager of the Society, was well attended and after three hours, was adjourned to the next day when, under the gavel of Vice-President F. R. Low, the discussion extended over two hours.

The session was opened by reading the following brief of Dr. David H. Ray's[1] paper on Appraisal and Valuation Methods:

The outstanding feature of the paper is the method of integration of value by weighted average. This method cannot easily be applied by accountants because they do not know how to determine the coefficients.

[1] Professor of Industrial Engineering, California Institute of Technology, Pasadena, Cal.

Members of St. Louis Local Committees, Whose Efforts Contributed So Fully to the Splendid Success of the Meeting

General Committee
M. L. Holman
Hon. Chairman
Louis C. Nordmeyer
Chairman
Lewis Gustafson
Vice-Chairman
Fred. E. Bausch
Secretary
William P. Samuel
Treasurer
Ernest L. Ohle
H. Wade Hibbard
Chester B. Lord
Edward W. Schadek
Victor J. Azbe
Edward R. Fish

Reception Committee
Roderick H. Tait
Chairman
A.S.M.E. St. Louis Membership

Women's Committee
Mrs. Ernest L. Ohle
Chairman
Mrs. Edw. R. Fish
Vice-Chairman
Wives of the Associated Engineering Societies Membership

Hotel Committee
William H. Reeves
Chairman
Joseph W. Peters
Vice-Chairman
E. Julius Boehmer
William E. Doll
Robert F. Wiselogel

Publicity Committee
Victor J. Azbe
Chairman
Edmond Siroky
Walter Siegrist

Finance Committee
Philip DeC. Ball
Chairman
John F. O'Neil
William M. Duncan
Hugo Wurdack
Louis C. Nordmeyer

Program Committee
Ernest L. Ohle
Chairman
H. Wade Hibbard
Vice-Chairman
Robert G. Clyne
Dwight T. Farnham
George S. Hessenbruch

Entertainment Committee
Fred. E. Bausch
Chairman
Frank N. Jewett
Arthur S. Hawks
Charles F. Frede
George B. Evans
Leonard A. Day
Stevenson A. Dobyne
Edward H. Tenney

Information Committee
Edward R. Fish
Chairman
Nathan Kohn
Fred Key
Lyman C. Huff
William A. Hoffman
Edward L. Dillon
Ray L. Howes

Transportation Committee
Walter E. Bryan
Chairman
James E. Allison
G. Horton Blackman
Franz A. Berger
Henry F. Gauss
Allen C. Staley
B. Frauenthal

Meetings and Program Committee in General Charge of the Society's Conventions

Dexter S. Kimball
Chairman
A. L. De Leeuw
W. G. Starkweather
R. V. Wright
J. W. Roe

The second feature is the development of an "aleatory factor," which applied to modified original cost or reproduction cost, gives going value, must be based on the bed rock of theoretical economics and developed by experience and judgment in industrial engineering.

The basic economics is contained in John Stuart Mill's Principles of Political Economy, volumes I and II, a striking paragraph being:

> "The result of this long investigation may be summed up as follows. The economical progress of a society constituted of landlords, capitalists and laborers, tends to the progress enrichment of the landlord class; while the laborer's subsistence tends on the whole to increase and profits to fall."

Normally by general economic law profits tend to become less, and laborers normally find themselves in a tighter position with the years, for subsistence; in other words the mechanism of fundamental world economics normally reduces profits and increases cost of living (and demands for wages).

The way out of the dilemma is mechanical research and development. Here the skilled judgment of the industrial engineer comes into play and he must allocate the values and profits according to the various factors concerned in production and develop an aleatory factor which will differ with the class of business and its location.

It is to be noted that accounting systems often carry land valuation at cost until sale or appraisal as our modern economic industrial line up tends broadly "to the progressive enrichment of the landlord class," this may or may not be a factor in fair valuation. It however requires consideration in the formulation of a just aleatory factor.

In general therefore the determination of the aleatory factor is to be determined by an allocation of the elements of risk in the project considered along broad economic lines and modified by the special peculiarities of the business and its situation.

In presenting his paper on Price Levels in Relation to Value, Cecil F. Elmes[2] quoted John Stuart Mill's definition of value as "the value of a thing is its general power of purchasing, the command which its possession gives over purchasable commodities in general." Price he defined according to the New Standard Dictionary as "the amount demanded by an owner in return for an article as the condition of sale. . . . the quantity of labor which its possessor will take in exchange for it."

After showing the results of historical studies of commodity values and wages Mr. Elmes stated his conclusions as follows:

a It is of the utmost value to all of us and certainly to those engaged in the public utility business that precise use of the terminology of economics be insisted upon.

b Low commodity prices while superficially desirable may be in a broad sense the reverse of a blessing. Inasmuch as they signify a shrinkage in demand in commodity markets, they may be an indication of depression or stagnation in business.

c High prices—so long as they do not run into panic or famine prices—may equally be by no means an economic evil. Panic and famine prices are and should be within the control of the community and their evil effects can be largely eliminated by a wise use of that control.

d A great and progressive movement in the conditions of the laboring man is without question a large factor in the high prices of the present day.

e Every public-spirited citizen, having the welfare of the community at heart, and conversant with the evil of low wages, desires to see labor get just recognition and every incentive to progress and development.

f Outside of catastrophic disturbances which we cannot undertake to predict, a belief in lower commodity prices in the immediate future is hard to justify unless lower wages are taken for granted.

g The general laws of economics apply to public utilities just as much as to other lines of commerce, and every procedure and decision based upon the theory that economic laws apply to everything else except to public utilities is essentially unsound and vicious.

h In determining the rates of a public utility (and for that matter in any proceeding as between any two litigants before any tribunal) the word "dollar" should not be used to mean two different things, a high figure to one party and a low figure to the other party in one and the same controversy.

Rational Valuation—A Comparative Study, was the title of the paper presented by J. R. Bibbins[3]. The author called particular attention to the complex stage that the valuation problem had reached, and to the fundamental similarity between industries and utilities from the various aspects of valuating physical properties. He gave the results of an interesting historical study of an electric-railway property covering thirty years of the horse-drawn life, and its period of transition to electric propulsion up to the present day. This showed the rates earned over the period, the increase in net investment and the effect on deficit and surplus of varying rates of return. After considering the financial plans for rate-making purposes, and making a plea for a careful consideration of the present vague terminology of valuations, Mr. Bibbins closed as follows:

Is it not clear that the vagaries and inconsistencies of appraisal procedure could have been largely avoided thus:

1 By closer study of past history
2 Economic research into all fundamental facts
3 Reasonable forecast of future income and liabilities
4 More complete appraisal reports dealing with every aspect of reasonable value
5 An open mind—not trying to find the answer before we start
6 Acceptance of accrued depreciation as a physical fact to be handled like any other actuarial problem
7 Cost to reproduce theory used judiciously to reflect the original cost as nearly as possible
8 Institution of perpetual inventories and values based upon well-maintained and preserved records
9 Development of flexible or sliding-scale methods as bases for rates, service and return on investment
10 Adopting for utilities the practice of progressive industry in preserving its physical and economic integrity. Pay down "while the paying is good"
11 An attempt to educate rather than to obstruct or defeat Public Policy?

The paper entitled Data on the Cost of Organizing and Financing a Public-Utility Project, prepared by F. B. H. Paine,[4] was reviewed by Mr. Bibbins. Mr. Paine's paper presents the data accumulated in a report on a particular problem. He outlines the preliminary steps in the development of a public utility involving an expenditure of money. He analyzes these expenditures and upon the basis of his investigation concludes that the proper percentage for each of the following three heads is as follows:

The development of the project	2.5 per cent
The cost of money	5.0 per cent
The promoter's remuneration	5.0 per cent

Prof. H. C. Anderson[5] was unable to be present and his paper, The Construction Period, was also reviewed by Mr. Bibbins. This paper was presented to show in specific terms the relation of the construction period to the assignment of portions of construction cost known as overhead. These items of cost are items which must go into the property but which cannot be assigned as rails and ties are assigned. Professor Anderson's paper discussed proper allowance to be made for interest and taxes during the period of construction, items frequently ignored in early days of appraisal and too often exaggerated lately. His conclusion was that the proper interest charges can only be determined by a thorough study of the particular property under consideration with a view of determining: (1) The magnitude of the property, (2) the method used in finding the reproduction cost, (3) the proper construction period, and (4) knowing the construction period, what is the proper method to use. In determining the percentage to be allowed for taxes the author is of the opinion that the proper amount depends: (1) on the length of the construction period, (2) what percentage of the construction cost the assessor will find, and (3) the tax rate.

Mr. Elmes' paper was opened for discussion first and J. N. Chester,[6] commenting on the inflation of the dollar shown by Mr. Elmes, suggested that instead of attempting to change the valuations with corresponding changes in money value, the rate of return on money be changed. Mr. Chester stated that it was his belief that when the purchasing power of money decreased the compensation should increase and that this was the simplest form in which experts' opinions and lawyers' pleadings might be placed before courts and commissions as means of compensating capital.

Harold Almert[7] discussed the importance of considering that the dollar in which the property was valued was also the dollar with which the service must be paid for. He also expressed the desire that the engineer should familiarize himself with the matter of appraisal and valuation so that he should be in a position to guide the courts rather than be guided by tradition and precedent.

James E. Allison,[8] commenting on Mr. Chester's idea of adjusting the rate of return, mentioned some of the difficulties involved. He spoke of the values that a utility has, based on its desirability and based on an identical property reproduced new. He accentuated the point that getting a valuation without considering the elements of return is a very difficult procedure.

Mr. Bibbins called attention to the important part of Mr. Elmes' paper, that the dollar should not mean two things to two different people. He called attention to the difficulties thus far brought out in the discussion of both methods suggested: (1) holding value steady and varying the rate to absorb fluctuation in purchasing power, and (2) boosting property value and holding to return cost of money and rate of return on money at present in vogue. Mr. Bibbins was of the opinion that changing property would cause some embarrassment later, even though the present-day prices might continue.

[2] Sanderson and Porter, Chicago, Ill.
[3] Consulting Engineer, Chicago, Ill. Mem.Am.Soc.M.E.
[4] Deceased. Formerly Consulting Engineer, Paine, McClellan & Campion, New York.
[5] Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. Mem.Am.Soc.M.E.
[6] Chester and Fleming, Pittsburgh, Pa. Mem.Am.Soc.M.E.
[7] Consulting Engineer, Chicago, Ill. Mem.Am.Soc.M.E.
[8] Consulting Engineer, St. Louis, Mo. Mem.Am.Soc.M.E.

E. H. Whitlock,[9] offered the solution that commodities, wages, and prices of all other articles should more or less be based on the increase in money circulation per capita.

A discussion by Bion J. Arnold[10] was read. Mr. Arnold made a strong plea for complete valuation surveys, using the various elements necessary to satisfy the purpose of the valuation, and for a consideration of the same principles in valuation for utilities that are used in industries in determining cost of service, which has been neglected in the past. He stated that in his belief much of the antagonism between corporations and the public may be ascribed to application of various intangible values without regard to the character of the project, such as contractual relations under which it is organized, efficiency of administration, etc. He decried the use of expediency in present controversies over current pricing in appraisals. In this connection he stated that current pricing is directly applicable in some instances for sales, renewals, etc., but warned against the confounding of fluctuating purchase price of money with basic capital induction and the consequent embarrassing situation of being obliged to apply this same theory, current pricing, to properties at a time when prices have slumped far below normal or cost. He pointed out that if high prices are to remain, capital investment must rise gradually, due to high prices of renewals, capital investment reaching ultimately a new higher level which, however, cannot be reached suddenly as some desire for all purposes except taxation. He emphasized the importance of amortization of that part of the capital investment which is liable to be dissipated through future developments as a factor of cost of production as great as the cost of current maintenance of the property. In closing, Mr. Arnold made a particular plea for a classification of the terms used in valuation and appraisal.

C. E. Grunsky[11] stated that in his opinion, in the matter of valuation procedure the engineering profession should establish the guideposts of progressive thought courageously, fairly and without undue dependence upon leaders' precedents, giving due weight to the decisions of the courts and commissions but only in so far as these are sound in the light of true engineering economics. As a solution of the present difficulties caused by changing values of money, Mr. Grunsky suggested the establishment of a definite commodity unit to supplement money, which will be based not on metals but on things which in civilized communities are necessary to meet the wants of man, based on definite quantities of staples such as food and fuel, iron and such of the many other things which a family requires to live in ordinary comfort. The commodity unit would be incomparably more stable than the dollar. Mr. Grunsky further suggested that the change of value of the money unit as measured by the commodity unit might be used to secure a correlated increase or decrease of public utility earnings, thus making frequent revaluation for current prices unnecessary.

In a discussion of the contributions of Messrs. Arnold and Grunsky, Mr. Allison questioned the value of principles adopted by engineers in an attempt to upset the dicta of the courts and expressed himself as being opposed to a codification of laws of appraisal and valuation by the Society. Mr. Chester spoke again on the impossibility of solving the problem of proper rate return by simultaneously raising the base and the rate.

In response to the questions raised on discussion, Mr. Elmes replied that the unquestioned right of the state to regulate commerce within its borders applied as much to a fish store as it did to a street railway and that one law or one rule of fair dealing should apply to both. Touching on the point of the relation of expansion of currency to present rise in prices, Mr. Elmes said that a study of the 1896 dollar showed that in 1919 its purchasing power had shrunk to about thirty cents, inflation of currency alone reducing the purchasing power to thirty-nine cents. He stated that in his opinion the inflation of the dollar would not go down to any serious degree in the near future and quoted Prof. Irving Fisher as saying that it looked like fifty years before we could hope for a return of prices prevalent a year ago.

A written discussion presented by B. J. Denman[12] was read. Mr. Denman confined himself entirely to the question of valuation of public utilities and called attention to the fact that the reason for the decrease in the value of securities bearing a fixed rate of return, has been the lessened value of the return on account of the decreased purchasing power of the dollar. He also showed that the common stocks of utilities decreased in value, due to the inability of utility companies to promptly pass on to their consumers increased costs of operation. Mr. Denman made a plea for fair treatment of public utilities, and in this connection emphasized the importance of "Going Concern" value, which he believed should include the following elements: Value of established business; early losses; cost of establishing business; unamortized superseded property; cost of consolidation; good will. Mr. Denman was also of the opinion that the terminology of valuation should receive careful consideration, and when formulated be given wide publicity.

In a written discussion R. H. Nexen[13] called attention to the difficulty of obtaining true cost of commodities, because of wide fluctuations in market value, and gave the results of an investigation to determine the true weighted average price paid for copper from 1904 to 1913, and also to determine whether an average base price of wire and cable could be determined for this period, using as a base the price paid for fabricated wire and market quotations of Lake ingot copper during this period. He showed a very close agreement between the average method and the actual method.

Mr. Almert spoke concerning the variation in copper prices, due to the condition of the buying market rather than to economic conditions affecting the cost of production. He questioned the inclusion in the valuation of items which had been spent in original costs of installation but which are not at present included—as, for example, a bridge built by a new railroad which is to be dedicated to a municipality.

Max Toltz[14] quoted from his experience in the building of steam roads the fact that supplementary expenses were added to the value of the road. Mr. Toltz expressed himself as being in favor of a careful study by all engineering societies of the problem of appraisal and valuation.

In answering Mr. Almert's question, Mr. Bibbins stated that he would follow the procedure of examining every possible phase of proper investment in the past, excluding nothing that pertains to a functioning property in public use, and then determine from the past records the ability of the company to amortize some of the old charges. Mr. Bibbins also stated that amortization should take place after a fair return has been paid. In closing Mr. Bibbins presented the following resolution which was adopted by the meeting:

IT IS MOVED that a Committee on Present Valuation and Appraisal be appointed by the President of the Society to review, digest and crystallize the essential features of the various papers and discussions already submitted to the Society for presentation in concise form to the next Annual Meeting for further discussion and definition; supplemented by such additional papers on fundamentals as may be submitted or requested by the Committee.

Local Session

AT the Local Session, Tuesday morning, May 25, over which E. S. Carman of Cleveland, presided, the following papers were presented: The Housing Problem, Nelson Cunliff; Industrial Housing, Leslie H. Allen; River Barges and Terminals, William S. Mitchell; Mississippi Valley River Transportation Activities, E. W. Schadek; Burning Eastern Coals Successfully on a Conveyor Feed Type Stoker, L. R. Stowe, and Tight-Fitting Threads for Bolts and Nuts, C. B. Lord. Mr. Allen's paper was published in abstract form in the June number of MECHANICAL ENGINEER-

[9] Gen. Mgr., Am. Fire Clay & Products Co., Cleveland, Ohio. Mem.Am Soc.M.E.

[10] Consulting Engineer, Chicago, Ill.

[11] Consulting Engineer (C. E. Grunsky Co.), San Francisco, Cal.

[12] Vice-President United Light and Rwys. Co., Davenport, Ia. Mem.Am. Soc.M.E.

[13] New York City.

[14] Toltz, King & Day, Inc., St. Paul, Minn. Mem.Am.Soc.M.E.

ING; those of Messrs. Schadek and Stowe in the May number, and Mr. Lord's in the April number.

Mr. Cunliff's paper presented a problem of nation-wide importance. Because of the fact that the Priority Board declared that water works took precedence over housing the demand for dwellings throughout the country is very acute at the present time. Government statistics show that during the war there were 1,040,000 marriages, people eligible for new homes, and that there were but 27,000 houses built during that period.

The people of St. Louis have formed a home and housing organization, the purpose of which is the erection and sale of homes to the people of that city. The lives of the purchasers are insured so that in case of death the property goes to their estate which relieves the housing association and the Chamber of Commerce of being put in the position of foreclosing on widows and orphans.

The homes built are 3-, 4-, and 5-room two-story houses with hardwood floors in the lower story, and cost from $4,400 to $8,800. In all cases these houses are sold for the actual cost, which can only be figured out after the building has been completed.

Max Toltz,[1] discussing the paper, told of the housing problem in St. Paul. He pointed out that there is a shortage of 3,500 dwellings and two-thirds as many 30 to 40-flat apartment houses at the present time. Four-room frame houses cost $4,200 (the same house was built in 1917-1918 for $1,900) and brick houses $5,500 to $6,200. The home-building association that had been organized has not had much success because the people could not afford to buy houses in spite of the fact that the association gave 80 per cent of the value of the house as a first mortgage. In South St. Paul where the new Armour plant has been completed, there is a shortage of 800 houses. Inasmuch as nobody else will undertake to build these houses, the Armour Company will be obliged to build and rent them to its employees.

Regarding business houses, such as manufacturing plants and jobbing houses, of which there is a very urgent need, it is expected that nothing will be done for the next twelve months, not only because of the high prices of labor and material, but because of the fluctuation in prices. Building estimates are given with a statement that the cost sheet is "good only for today and tomorrow," and for this reason $17,000,000 worth of work is held up at the present time. As soon as material and labor can be secured at a fixed price, it is expected that a great deal of building will be done.

In closing, Mr. Cunliff pointed out that Government figures show that building costs for residences and flats have increased 215 per cent since 1914. People have been educated to pay a very considerable advance in the cost of clothes, shoes and food, but not to pay 215 per cent increase in the cost of the homes in which they live; therefore something will have to be done to bring them face to face with the fact that building costs are up and are going to remain up. The work of the St. Louis Home-Building Association is to establish people in permanent homes which they will be proud of, proud to live in, and proud to possess.

Mr. Allen's paper on Industrial Housing because of his absence was read by title only. In a written discussion Henry Wright[2] strongly advocated the building of intelligently planned flats. It was impossible to produce a well-constructed detached house of even four or five rooms so as to sell it on a basis of $50 per month. It was, however, possible to build a given amount of living space in the form of a flat at from 60 per cent to 65 per cent of what it would cost for the identical space in an individual house. A double house could be built for 10 per cent less than a single house; a cross-party-wall house, providing for four individual two-story houses, would save at least 15 per cent per unit; and houses built in rows would save 10 per cent on the end houses and 20 per cent on the middle houses. In all of these cases fuel consumption would be reduced in about the same proportion as the reduction in cost.

[1] M. E., Toltz, King & Day, Inc., St. Paul, Minn. Mem.Am.Soc.M.E.
[2] Advisor in Allotment and Community Planning, New York City.

John R. Fordice,[3] formerly a terminal engineer of the Mississippi-Warrior Barge Line, who has made a special study of terminal conditions along the Mississippi River, in discussing Mr. Mitchell's paper, called attention to the fact that with the exception of St. Louis and New Orleans, there are no river ports providing the wharves and machinery for properly handling the cargoes which the river service is expected to carry. Among several reasons which he enumerated for the lack of terminals are: the great cost, lack of faith in the enterprise, and a lack of proper engineering and advice. The river conditions vary greatly each season; a bar may form one year where deep water existed the year before, and the course of the river may change and deep water may exist today where a town was situated last year. For these reasons the towns do not feel that they should attempt to build permanent structures.

To provide a terminal which will meet these conditions, a "terminal barge" was designed by the speaker. This barge is 250 ft. long with a 75-ft. beam and has two railway tracks, each of which holds five freight cars. It is provided with two cranes to handle heavy, unwieldy pieces of freight, eight conveyors to handle small packages, and pumps to handle liquids. This barge will anchor at the foot of a railway incline, the cars will be run on and the cargo will be transferred when necessary to river boats and barges with little difficulty. For local freight, a barge might be designed for horse-drawn vehicles and auto trucks which could be provided with removable bodies. The cargo will be unloaded either through hatches in the roof or through doors at the side, according to the stage of the river and the character of the cargo; therefore it should be easy to transfer cargo, of whatever nature, quickly and cheaply. At the present time none of these barges are in operation, but it is expected that one, now nearly completed, will be tried out in St. Louis in the near future.

Charles Whiting Baker,[4] in a written discussion, took up the subject from an economic standpoint. He pointed out that an investment of $157 per ton, which would be required for three barges and one tow boat, is a much larger investment cost than would be required for cars and a locomotive to move the same amount of freight. The crew—40 men to move 4500 tons of freight—is much larger than the train crew necessary to move such a tonnage by rail. The risk of transportation by river or canal is greater than that by ocean or lake and many times greater than that of rail transportation, and risk is an important element of cost. If private investors were asked to put their money into such an enterprise, such an estimate would have to be presented; therefore it follows that the United States Shipping Board, which is investing the taxpayers' money, should investigate this matter carefully and determine whether or not the investment will prove profitable.

In answer to a question raised by Melvin Overstrud[5] as to whether or not any investigation has been made of the feasibility of running from Stillwater, Minn., south instead of from Minneapolis and St. Paul, John N. Chester[6] asked whether or not such investigations were profitable. He pointed out the tremendous waste of money in maintaining the inland waterways of the country from which so little return is realized. He recalled the drydock at Keokuk, practically idle, and the ship locks which, with the exception of a few excursion boats, served only a small packet, which uses it twice a week at an expense of $5000 to the Government. In addition to this he mentioned the tremendous expense of the construction and upkeep of the 53 dams of the Ohio River and of the New York State Barge Canal, for all of which there was but a very small return.

John H. Bernard[7] reviewed European practice (Germany and Holland) in regard to waterways, and pointed out that because of the development in these countries the railroads have to be

[3] St. Louis, Mo.
[4] President, Baker Economic Transport Corporation, New York City. Mem.Am.Soc.M.E.
[5] Asst. to President, Twin City Forge & Foundry Co., Stillwater, Minn. Jun.Am.Soc.M.E.
[6] Chester & Fleming, Pittsburgh, Pa. Mem.Am.Soc.M.E.
[7] Transportation Engineer, New York City. Assoc-Mem.Am.Soc.M.E.

protected against them. One of the main reasons why there is not more water transportation in the United States is because of the lack of suitable terminals. Railroads spend a large percentage of their income on their terminals, whereas the percentage spent by barge lines is practically negligible.

J. R. Bibbins[8] discussed the results of a comprehensive investigation made in New Orleans to determine the probable distribution of the freight movements in this country. Taking Gibraltar, Pernambuco and the Panama Canal as the basing points for export rates, it was found that for non-European ports, traffic originating south and west of a curve running from Savannah east of St. Louis and up through the northwest should move via the Gulf: for the east coast of South America all freight originating west of the line passing near Chicago should move via the Gulf; and for the west coast of South America and Pacific ports all freight west of the curve passing through Buffalo should move via the Gulf. But the fact was that the freight did not move that way; and the reason therefor was one of the biggest fundamental problems of industrial economics that existed in this country.

Theodore Brent[9] told of the activities of the Mississippi-Warrior River division during the war. He pointed out that within the last twenty years there has been no boat service on the lower Mississippi until the Government proposition was tried. During the régime of the U. S. Railroad Administration railroad river rates were secured by means of which the man living inland received the benefit of saving of what was considered, up to the present time, the proper relation between rail and rail and water rates. The fact had been demonstrated that river rates could be made that would be at least 20 per cent below rail rates, and not only save money for shipper and consumers, but pay the cost of operation as well.

Mr. Schadek accompanied the presentation of his paper by lantern slides, which showed the types of boats being built under the governmental program. He called attention to the Newton Bill now pending in Congress, which provides for the dredging of channels in the Ohio, Missouri and Mississippi Rivers, and referred to the fact that because of the importance of river transportation, the state of Illinois had appropriated $20,000,000 for the purpose of making improvements on the Chicago drainage canal.

John H. Bernhard expressed his opinion that the river terminals are not built properly. He emphasized the fact that freight must move continually and rapidly, and that removing freight by means of a vertical lift is not the best method. He pointed out the advantages of self-propelled barges in crooked rivers, and as the introducer of this type of barge expressed his regret at the present time, as he felt they could not be successful in such rivers as the Warrior, which had a number of bends of 24 ft.

Charles Whiting Baker submitted a written discussion to the effect that water transportation could in no way compete with rail transportation. Ninety-five per cent of the freight moved by rail, he wrote, is carload freight which is loaded by the shipper and unloaded by the consignee. It costs more to move a ton of freight by wagon or motor truck than to haul it 200 miles by rail. This handling is nearly always necessary with boat transportation, whereas by rail most of the carload freight is taken from and delivered to the private sidetrack of the mill, mine or warehouse. Hopper-bottom cars, which drop their load directly into the boiler-house bins, have an advantage that the floating barge cannot possibly overcome. He maintained that the burden of proof was on the waterway advocates to demonstrate, by estimates that would bear critical analysis, that freight can be moved at enough lower cost by water than by rail to induce capital to undertake the building and operating of boats. Until this was demonstrated, business would not be restored to the rivers, no matter how much more the Government spends on their channels.

[8] Consulting Engineer, Chicago, Ill. Mem.Am.Soc.M.E.
[9] U. S. R.R. Administration. Mgr. of Mississippi-Warrior River Division.

R. A. Hiscano,[10] in a written discussion of the Mitchell and Schadek papers, pointed out the value of river transportation in the East. The last two months had shown conclusively that the statement made that the rail transportation systems were entirely able to take care of the country's business was far from the truth. If it had not been for the boat lines operating out of New York City to Hudson River, Long Island Sound, and New York Bay points, conditions during the past year would have been considerably worse than they were. The lack of room in New York and vicinity in which to expand rail terminal facilities made it imperative that the waterways be utilized.

Mr. Stowe illustrated his paper by means of lantern slides. R. H. Kuss[11] and R. Sanford Riley[12] paid tribute to the originality and intelligence with which the paper was worked up. Each, however, commented on the lack of data and expressed the opinion that more should have been given. Mr. Riley pointed out that hitherto experiments in mechanical stoking had perhaps neglected to give sufficient attention to the chemical side of the problem. Such a procedure as Mr. Stowe followed, he said, opens up an entirely new field and is a real contribution to the art.

Written discussions by Donald H. Hampson,[13] Wilfred Lewis,[14] and H. L. Van Keuren[15] were submitted for C. B. Lord's paper. All were impressed favorably with the idea of putting the Sellers nut on a Whitworth bolt, and welcomed this scheme as a very good solution of a perplexing problem. Mr. Lewis, however, pointed out that this scheme would develop a rivet-like joint which it would be necessary to either twist or cut apart. For the most part, nuts are put on with the idea of taking them off if necessary, therefore considerable experimental work must be done to determine the safe limits in the materials used.

Aeronautic Session

FOUR noteworthy papers were presented and discussed at the Aeronautic Session held Wednesday morning, May 26, Dean Charles Russ Richards presiding. These papers were: Physical Basis of Air-Propeller Design, F. W. Caldwell and E. N. Fales; Analytical Theory of Airplanes in Rectilinear Flight and Calculation of Maximum Cruising Radius, A. Rateau; Aeronautic Instruments—General Principles of Construction, Testing and Use, Mayo D. Hersey; and Flow of Air Through Small Brass Tubes, T. S. Taylor.

Messrs. Caldwell and Fales' contribution was exceptional, their paper, The Physical Basis of Air-Propeller Design, being given by Mr. Fales with the aid of moving pictures which showed very clearly eddies and vortices in air moving against an aerofoil in the wind tunnel. This paper appeared in abstract form in the April issue of MECHANICAL ENGINEERING.

Walter C. Durfee[1] submitted a written discussion of the paper in which he stated that if it was possible for an end of a wing to fail while the other continued to lift, as stated by the authors, numerous accidents might be looked for as one would expect an airplane to turn over sideways under such circumstances. He thought that further information of interest could be furnished by the authors concerning the need for the straighteners and just why they were located with reference to the wind tunnel as they were. It seemed probable to him that the nuclei for fog condensation in the model wing expediments were not of a chemical or electrical nature, but were certain microscopic regions of low pressure existing in the centers of axes of various small eddies.

M. C. Stuart[2] wrote calling attention to the advantages of the specific-speed method of dealing with geometrically similar air propellers in connection with their design, and referred to a

[10] General Manager, Catskill Evening Line, New York City.
[11] M. E., Malcolmson Briquet Engng. Co., Chicago, Ill. Mem.Am.Soc.M.E.
[12] Pres. Sanford Riley Stoker Co., Worcester, Mass. Mem.Am.Soc.M.E.
[13] M. E., Morgan E. Wilcox Mfg. Co., Middletown, N. Y. Assoc.Mem.Am.Soc.M.E.
[14] Pres. The Tabor Mfg. Co., Philadelphia, Pa. LifeMem.Am.Soc.M.E.
[15] Gage Engineer, Wilton Tool & Mfg. Co., Boston, Mass. Assoc.Mem.Am.Soc.M.E.
[1] Consulting and Manufacturing Chemist, Winthrop C. Durfee, Boston, Mass. Mem.Am.Soc.M.E.
[2] M. E., U. S. Naval Engineering Experiment Station, Annapolis, Md. Mem.Am.Soc.M.E.

paper on the subject which he had contributed to the Journal of The American Society of Naval Engineers in May, 1918.

Morgan Brooks[4] said that he was impressed with the definiteness at which the discontinuity was fixed by the experiments described, and also by the superiority of the motion-picture method used by the author over the old method of point-by-point tests. There was some suggestion toward the end of the paper in regard to discontinuity having an influence on very high-speed flight. We were now reaching speeds of 600 to 700 ft. per sec. at the tip of the propeller, perhaps more, and as it had always seemed to him that discontinuity must come at the velocity of sound in air, that is, 1100 ft. per sec., in designing we might have to take account of discontinuity.

Mr. Fales, in closing, said in reply to Mr. Durfee that the energy at the tips of an airplane was a very small percentage of that in the air flow and he doubted whether the amount would be enough to upset the airplane. The use of a straightener to decrease the pulsations in the wind tunnel was the result of experiments made by Mr. C. P. Grimes and himself and was suggested originally by the flow out of a bathtub. It was found that it was possible to stop the whirl by means of such straightener as had been used.

Replying to Professor Brooks, he said that the moving pictures and photographs were vastly inferior to the actual view of the phenomenon in the wind tunnel itself. The effect of the discontinuity had already changed over the design to some extent, but he doubted whether this phenomenon would affect an airplane very greatly.

Dr. Rateau's paper on The Analytical Theory of Airplanes in Rectilinear Flight and Calculation of Maximum Cruising Radius, was presented by Prof. George O. James of Washington University, who outlined the mathematical reasoning of the author, from which the conclusion was drawn that the maximum cruising radius of an airplane today is about 4350 miles. An abstract of Dr. Rateau's paper appeared in the May issue of MECHANICAL ENGINEERING.

Walter C. Durfee, discussing the paper, wrote that since the sole object of attaining the high altitudes mentioned by the author, so far as cruising radius was concerned, was to cut down the tractive force while maintaining a perfect carburetion of fuel, it would seem that the same thing could be otherwise arranged for, as by cutting out some of the engines in case there were several; or the plane could be flown constantly at its most economical speed, allowing the surplus tractive force to be stored as potential energy of elevation, which could be used up from time to time by shutting off the engine and allowing the machine to glide. The cruising radius would then be somewhat greater as compared with the high-altitude radius, because the flight might be accomplished at a low level where the internal losses of the motor would be a small proportion of the total expenditure of energy.

J. G. Coffin[4] wrote that the author went much more into the detail of the subject than practical considerations necessitated. He had treated the question of aeroplane ranges in a paper prepared in 1918 and which had just been issued as Report No. 69 of the National Advisory Committee for Aeronautics. In this paper his aim had been to introduce the least number of complications possible and derive a practical method for giving an estimate of possible ranges. Conclusions similar to his had since been published in French, English and Italian reports. The main factors to be taken care of were evidently the propeller efficiency, the fuel consumption per horsepower-hour, and the L/D ratio for the complete plane loaded to plane empty.

E. N. Fales[5] submitted an extended written discussion in which he gave calculations, based on data taken from actual flight tests made in February at McCook Field, showing that speeds of 300 m.p.h. were possible with the Thomas-Morse M. B. 3 aeroplane tested, providing its propulsive power were maintained constant by supercharging the engine (a 300-hp. eight-cylinder Hispano-Suiza) and applying an adjustable-pitch propeller. This would mean New York to St. Louis in four hours.

Morgan Brooks said that near the close of the paper the author added one per cent to the cruising radius by planing down after all the gasoline had given out, but he had not allowed for the extra fuel it required to originally reach the altitude. Having allowed nothing for rising he thought the author was not entitled to claim the extra distance for coming down without gasoline.

In presenting his paper on Aeronautic Instruments, Mr. Hersey outlined the important work done by the Bureau of Standards in this department and supplemented it with slides showing additional types of instruments tested by the Bureau. This paper, slightly abridged, was published in the May issue of MECHANICAL ENGINEERING.

Alexander McAdie,[6] discussing the paper, wrote that the typical altimeter as described by the author would show an error of 8 per cent at 25,000 ft. elevation and the outstanding need was for a temperature correction. It was a fact that Doctor Jeffries, who crossed from England to France through the air in 1785, could tell his maximum elevation (6600 ft.) with his mercurial barometer with much greater accuracy than a present-day flier with an altimeter.

The atmosphere had been quite well explored and pressure, temperature and humidity conditions determined for heights far beyond airplane or airship limits. The lowest temperature in the air thus far obtained was — 130 deg. fahr. at 17,000 m. elevation over the equator. A temperature scale successfully used for several years at the Blue Hill Observatory had its zero at absolute zero and 1000 for the freezing point. This eliminated minus signs and degree symbols and was known as the 4 K system.

It seems to be impracticable for an aviator to determine the true velocity while both machine and air were in motion, but by sending him from a certain point a combined wireless and sound signal, a close approximation of his distance from the source could be made. The interval between the arrival of the two signals made simultaneous would give the time of travel of the sound or aerial wave, and the proper correction for temperature and density, the distance.

Elmer A. Sperry,[7] in a written discussion, called attention to the unreliability of the magnetic compass in fog, cloud and night flights. It was highly reliable in straight flight, however, but this was extremely difficult when no landmark could be seen. The gyroscopic turn indicator he had developed had been made to indicate clearly a turn about a radius as great as five miles, distinguishing clearly between this and straight flight; and by thus safeguarding the magnetic compass very excellent navigation had been secured. The great advantage of dealing with true geometric meridians and the high degree of accuracy attained by the gyroscopic compass made it very desirable for large aircraft.

Albert F. Hegenberger[8] wrote concerning the work of the Engineering Division, Air Service, in developing aeronautical instruments, especially those for military work. A new sensitive barograph which had been functioning successfully for several months would record a change in altitude of about 30 ft., and a mechanical rate-of-climb meter now being tested out used a sylphon for the sensitive diaphragm element and had worked very well. Aeronautical instruments, however, were still very far from satisfactory. Gyroscopic compasses thus far tested had been affected so greatly by bumps and similar accelerations as to be worthless. Turn indicators of the gyrostatic type should be improved to prevent oscillations of the hand, which were very confusing. The static-head type was free from this vibration, but was affected by side slips and skids. A great many instrument problems would be solved if some means could be developed for indicating the true vertical and horizontal. Increasing reliance was being placed on instruments as they continued to im-

[3] Professor of Electrical Engineering, University of Illinois, Urbana, Ill. Life Mem.Am.Soc.M.E.

[4] Director of Research, Curtiss Aeroplane & Motor Corpn., Garden City, L. I., N. Y.

[5] Air Service, Engineering Department, McCook Field, Dayton, Ohio.

[6] Director, Blue Hill Observatory (Harvard University), Readville, Mass.

[7] President and Engineer, The Sperry Gyroscope Co., Brooklyn, N. Y. Life Mem.Am.Soc.M.E.

[8] Second Lieut., A. S. A., Air Service Representative, Dayton, Ohio.

prove and it was not at all improbable in the near future that large aeroplanes and planes with enclosed cockpits would be flown entirely by instruments.

J. A. Hoogewerff[9] wrote that Mr. Hersey did not sufficiently stress the point that it was most necessary for the air pilot to have a thorough knowledge of the instruments available for his use and respect for them based on that knowledge. He should be sufficiently informed to make due allowances for instrumental errors and inaccuracies, but he should also realize that good instruments are far more accurate than human judgment and that to depend on judgment alone might be fatal.

Thomas D. Cope,[10] in a written communication, stated that an experimental gasoline depth gage tried out at Langley Field had given excellent service and reliable indications. Its new features consisted of a ball-and-socket endless chain running over pulleys and actuated by a float. The motion of the upper pulley was communicated through a ground joint to a rack and pinion and thus by a wire to a dial and pointer on the instrument board.

In closing Mr. Hersey said, apropos of Admiral Hoogewerff's remarks on the need for training pilots, that it might be of interest to those present to know that the Aeronautic Instrument Section at the Bureau of Standards had conducted two schools during the war in which scientific courses were given to naval officers to fit them to take charge of instrument work in the Navy. This was done at the request of the Chief of the Bureau of Operation. He felt that the discussions that had been presented were all useful contributions to the subject of the paper.

Mr. T. S. Taylor's paper on the Flow of Air through Small Brass Tubes appeared in June MECHANICAL ENGINEERING. Mr. Taylor was unable to be present and his paper was presented by title.

H. Wade Hibbard[11] said that while Mr. Taylor's tests showed that for a tube 1½ in. in diameter it required a length of flow of 50 diameters to reach a stable condition, he would state that in large conduits the case was different. He had found that in transporting sawdust and shavings by air blast through a 3-ft. metal conduit 800 ft. long, if a piece of metal accidentally fell into the material being transported, it would dent the conduit its entire length, and that the dents would be apparently as numerous toward the end as at the beginning.

Mayo D. Hersey asked if the author had compared his experimental results with the well-known formula of Dr. Lees. This was recognized in England as covering the law of the flow of fluids through any form of pipe, and it would be of value to have the comparison made.

Castings Session

THE Castings Session convened on Wednesday morning, May 26, with F. O. Wells, Manager of the Society, presiding. The session was organized by the former Sub-Committee on Foundry Practice as a symposium on the various types of castings and the papers, including information as to what may be obtained from commercial foundries, are of great value to designing engineers. The symposium consisted of the following papers: Malleable Castings, Enrique Touceda; Die Castings, Charles Pack; Aluminum Castings, Zay Jeffries; Steel Castings, John H. Hall; Gray-Iron Castings, Richard Moldenke, and Brass and Bronze Castings, C. H. Bierbaum. Dr. Moldenke was present as the representative of the Foundry Committee and guided the discussion which culminated in an expression of desire to hold further meetings to consider the foundry problems of the engineer. Mr. Pack was also requested to present a treatise on die castings for the Annual Meeting.

The castings papers, together with an account of the discussion which they elicited, will appear in abstract form in a future number of MECHANICAL ENGINEERING.

[9] Rear-Admiral U. S. N.; Supt. U. S. Naval Observatory, Washington, D. C.

[10] Assistant Professor of Physics, University of Pennsylvania, Phila.

[11] Professor of Mechanical Engineering, University of Missouri, Columbia, Mo. Mem.Am.Soc.M.E.

Scientific Session

THE Scientific Session on Thursday morning was a joint session with the American Society of Refrigerating Engineers and the American Society of Heating and Ventilating Engineers, both of which organizations were meeting in St. Louis for their spring conventions. Mr. Matthews, president of the American Society of Heating and Ventilating Engineers, presided at the meeting and five papers were presented, three being contributed by The American Society of Mechanical Engineers, and one each by the Refrigerating, and Heating and Ventilating Engineers. These papers and authors were as follows: An Improved Form of Weir for Gaging in Open Channels, by Clemens Herschel; Simplification of Venturi-Meter Calculations, by Glenn B. Warren; The Dissipation of Heat by Various Surfaces, by T. S. Taylor; The Thermal Conductivity of Heat Insulators, by M. S. Van Dusen (contributed by Am. Soc. R. E.); and Ship Ventilation, by F. R. Still (contributed by A. S. H. & V. E.).

Of the papers presented by The American Society of Mechanical Engineers, that by Mr. Herschel appeared as the leading article in the February issue of MECHANICAL ENGINEERING (p. 83), while the papers by Messrs. Warren and Taylor will be found in abstract form in the April issue, on pages 220 and 230, respectively.

Mr. Herschel's paper, presented by F. R. Low,[1] outlined the results of a series of investigations on weirs which mark a distinct step forward in the measurement of water by that means. The investigations were undertaken at the instigation of the Power Test Code Committee of The American Society of Mechanical Engineers and the necessary funds were supplied by Engineering Foundation. The new weir which is described in the paper bears no resemblance to the sharp-edged weir now in general use, for its crest is made in the form of an arc of a circle and is hollow for observing the pressure at that point. Mr. Herschel's tests showed that for discharge of from 0 to 9.55 cu. ft. per sec. per ft. of weir length, the limits covered by the experiments, the quantity of water flowing, Q, was directly proportional to the difference, d, in two pressures, one measured just upstream of the weir, and the other measured at the crest, the formula being $Q = 5.50\ d$.

In the discussion which followed A. M. Greene, Jr.,[2] stated that he was unable, by means of the formula given, to compute the results which were tabulated by the author. He therefore asked that Mr. Herschel furnish at least one set of the complete data so that he might be able to follow through the computations and accordingly check the values given. Professor Greene also asked why Mr. Herschel selected the position for the hook gage as stated in his paper when he claimed that hydraulic engineers do not know where to put the hook gage in the standard form of sharp-crested weir.

Dean R. L. Sackett,[3] in discussing the use of weirs now commonly employed, stated that the weir itself ought not to be condemned, but rather the methods employed in its use, for in the past there has been no agreement either upon a standard type or upon the position at which to measure the head. The new weir is not the only one in which sharpness varies as the head, as recent laboratory tests indicate that a sharp-crested weir of a standard curved type in vertical position does have a constant coefficient within the range of experiments made. It might therefore appear, Dean Sackett said, that the new weir is better for large volumes of water than the old type, but in the measurement of water used for cooling purposes or return water in power plants, a sharp-crested weir of standard type with a coefficient, one where the discharge would vary in its head, would be of great advantage.

C. G. Richardson[4] said that to his personal knowledge Mr. Herschel would be greatly pleased if the technical schools and colleges would study this problem and carry on investigations

[1] Editor, *Power*, New York. Vice-President Am.Soc.M.E.

[2] Professor of Mechanical Engineering, Rensselaer Poly Inst., Troy, N. Y. Mem.Am.Soc.M.E.

[3] Dean of Engineering, Penn. State College, State College, Pa. Mem.Am. Soc.M.E.

[4] Chief Mechanical Engineer, Taft-Pierce Co., Woonsocket, R. I. Mem. Am.Soc.M.E.

along the line he had suggested. He further stated that F. M. Connet,[5] in discussing with him the features of the new weir, had expressed the opinion that it seemed to be a special form of venturi tube and it should, therefore, be expected that the quantity flowing would vary as the one-half power of H, where H represents the difference in head between the inlet and throat of that special venturi tube. It seems possible, however, that the departure from the formula so that Q varies directly as the head may be due to the departure of the stream line from the true venturi principle as it passes over the contraction or, one might say, the throat of the tube.

The second paper of the session, Simplification of Venturi-Meter Calculations, by G. B. Warren, was presented by title only. It describes a method devised by the author which reduces the calculation of venturi-meter measurements to a simple slide-rule computation requiring but a few settings. Written discussions of Mr. Warren's paper were presented by Thomas G. Estep,[6] M. C. Stuart,[7] and C. G. Richardson.[8] Additional discussion will also be found in the Correspondence Section of this and the May issues of MECHANICAL ENGINEERING.

Mr. Estep in his discussion called attention to the fact that the equations developed by Mr. Warren are simple derivations of fundamental equations for the frictionless adiabatic flow of elastic fluids and credit is therefore due to older investigators than those mentioned by Mr. Warren. He also presented a formula which he had developed, with the suggestion that if it is desired to simplify the calculation that an impact tube be used instead of the upstream static opening, retaining, however, the static opening at the throat. The differential pressure then represents the total velocity at the throat instead of simply the change in velocity as when the two static openings are used. He also stated that in his opinion Mr. Warren's calibration shows that H. B. Reynolds'[9] empirical equation for a thin-plate orifice is a good one, but it does not prove the accuracy of the venturi meter.

M. C. Stuart stated that several years ago he had developed a method of simplified calculations almost identical with that presented in the paper, and in his discussion gave details of his method.

M. S. Van Dusen, of the Bureau of Standards, next presented his paper on the Thermal Conductivity of Heat Insulators, which dealt with the development of the methods for measuring the insulating properties of materials. Mr. Nichols, in discussing Mr. Van Dusen's paper, called attention to the necessity in heat-measurement work of settling upon a definite and very closely regulated method for absolute conductivity measure. Messrs. Cramer, McGeorge, F. R. Still, Voorhees, and L. R. Whitney also discussed the paper, commenting chiefly upon the excellent scientific work being done at the Bureau of Standards whose research work is of value to the entire country and not limited in application to any particular class of industry. This sentiment was the result of a suggestion by one of the discussers that the large industrial corporations might very profitably finance scientific investigations being carried out under the direction of the Bureau of Standards.

The paper by T. S. Taylor on the Dissipation of Heat by Various Surfaces, dealt for the most part with the value of sheet asbestos as a covering for hot-air furnace pipes. In addition to the oral discussion which follows, there were two written discussions, one by A. C. Willard and V. S. Day, of the University of Illinois, and one by L. R. Ingersoll, of the University of Wisconsin.

The discussion by Messrs. Willard and Day dealt chiefly with the first part of Mr. Taylor's paper. They pointed out that in general Mr. Taylor's results confirmed the work of a similar nature already completed at the University of Illinois and reported in Bulletin No. 117 of the Engineering Experiment Station as the Emissivity of Heat from Various Surfaces, by V. S. Day. In fact, when the results of the two investigators are compared on the basis of the excess of surface temperatures of the cylinders above the surrounding room temperatures, a satisfactory agreement results. Messrs. Willard and Day also pointed out that the only definite basis for estimating the amount of heat dissipated by thin metal surfaces which separate air or gas at high temperatures from air or gas at low temperatures, is the difference in temperature between the surface itself and the temperature of the cooler surrounding air. The values given by Mr. Taylor are used as a basis for a calculation, as the result of which they conclude that Mr. Taylor's values of the coefficient of emissivity when surface temperatures are used as a basis are only 5 to 6 per cent lower than Mr. Day's values for bright tin cylinders.

L. R. Ingersoll, in commenting upon the paper, stated that the results are by no means striking to one familiar with the main laws of heat transference. The effect would be exaggerated if the pipe were of very small diameter, for in this case the addition of insulation would add appreciably to the radiating surface. From a practical standpoint, however, furnace pipes are so generally dirty and dusty that to leave off the customary asbestos-paper covering in the expectation of saving heat would be a practice of doubtful wisdom.

L. B. McMillan[10] called attention to the fact that the author's conclusion that a thin layer of asbestos paper applied loosely to a bright surface increased the loss of heat from the surface, is undoubtedly correct and in accord with former tests of the same general nature. The increase in heat loss, he said, is entirely due to the change in character of the exposed surface. The addition of a thin layer of asbestos adds some resistance, but not enough to offset the decrease in surface resistance. In the case of furnace pipes the loss from the bright surface is so great that it would be wasteful to leave them bare. The important factor, therefore, is what one thickness of insulating material will save as compared with another. He also called attention to the superior insulating qualities of cellular construction and stated that actual tests at the University of Illinois on surfaces covered with three layers of air-cell asbestos showed a saving of twice that obtained by the same material by the author's calculations.

Mr. McMillan also stated that experiments have established the fact that radiation from a galvanized surface increases very materially as the surface becomes tarnished. Tests reported in *Engineering*, October 19, 1917, showed that galvanized iron exposed to the weather for one year offers practically no more resistance to radiation than does black iron.

E. R. Hedrick[11] called attention to the fact that the laws that were presented were for entirely different circumstances than the laws for the dissipation of heat when gas or other material is passed through the pipe, for in that case a very important consideration, especially as there is a considerable drop in temperature, is the passage of material down the pipe. However, since the experiments were conducted in a box of uniform size, agreement between the laws that are represented and the laws for the transmission of heat which apply for a material being passed through a pipe, is not expected. Mr. Hedrick also commented on the formula and curves given by the author, and stated that he had not succeeded in doing more than check the formula presented and in his opinion it did not hold. He also stated that the observations were limited because they had been carried on for a difference of only 10 deg., which in his opinion constituted an insufficient basis for argument for ordinary heat transmission.

J. D. Hoffman,[12] in commenting upon the value of Mr. Taylor's paper, stated that he considered it of especial value because of the fact that it confirmed the work that had been done at the University of Illinois and the results obtained were also in close

[5] Chief Engineer, Builders Iron Foundry, Providence, R. I. Mem.Am.Soc.M.E.
[6] Assistant Professor Mechanical Engineer, Carnegie Inst. Tech. Mem.Am.Soc.M.E.
[7] Mechanical Engineer, U. S. Naval Engineering Experiment Station, Annapolis, Md. Mem.Am.Soc.M.E.
[8] Sales Engineer, Builders Iron Foundry, Providence, R. I. Mem.Am.Soc.M.E.
[9] Trans. Am. Soc. M. E., vol. 38 (1916), p. 799.
[10] Construction Engineer, H. W. Johns-Manville Co., New York, N. Y. Assoc-Mem.Am.Soc.M.E.
[11] Professor of Mathematics, University of Missouri, Columbia, Mo. Mem.Am.Soc.M.E.
[12] Professor, Director of Practical Mechanics, Purdue Univ., Lafayette, Ind. Mem.Am.Soc.M.E.

accord with the work done by Mr. Soll, of the American Radiator Company in his investigation on blast heating.

The final paper of the session, on Ship Ventilation, was presented by F. R. Still [12] of the American Society of Heating and Ventilating Engineers. This paper, which appeared in the April issue of the *Journal of the American Society of Heating and Ventilating Engineers*, page 363, takes up the subject of ventilating passenger ships, refrigerating ships, cattle ships, general freighters, and lake and river steamers. There was no discussion.

Power Session

THE interest among mechanical engineers in the subject of power was evidenced by the announcement at the Power Session of Friday morning, by F. R. Low, that over 700 members had expressed a desire for a Power Section and that (as announced elsewhere) at a meeting previously held steps had been taken for the formation of such a Section. Prof. Robert H. Fernald presided at the Power Session and four papers were discussed as follows:

The first paper, by Otis L. McIntyre, New York, dealt with experiments on pulverized coal which led to the installation of apparatus for its use in the metallurgical furnaces of the Cerro de Pasco Copper Corporation at La Fundicion, Peru. These were unique in that they were conducted at an altitude of 14,000 ft., a condition under which there have been practically no data available. It should be said, also, that the paper itself is unique in that the difficulties encountered in the development of the apparatus are plainly stated. The pros and cons of pulverized fuel are all of interest to the engineer, but it has usually been easier to get at the pros than the cons in papers prepared on this subject.

W. N. Best,[1] the only one to discuss this paper, styled it as "excellent." His only criticisms were on the number of burners used and lack of combustion space provided. With pulverized coal as few burners as possible should be used—one burner will give better results than two or four because the flame and temperature can be more easily controlled by the operator. A combustion chamber is not only required for good combustion of the fuel, but will prevent the piling up of the unconsumed fuel before reaching the bath of molten metal.

The second paper, on Efficiency of Natural Gas Used in Domestic Service, by Robert F. Earhart, Columbus, Ohio, touched a vital point in the fuel situation in this country. The supply of natural gas is no longer sufficient for both industrial and domestic purposes; and under the present wasteful methods it will not long be sufficient even for the latter use. Anything contributing to greater economy in the consumption of gas in the thousands of homes in the natural-gas regions, therefore, is of the greatest importance. The paper reports the results of a series of efficiency tests on natural gas made in the physics laboratory of Ohio State University. The conclusions relate mainly to the location of the burner with respect to the utensil on the stove and show that with proper adjustment an efficiency in excess of 45 per cent can be secured.

G. I. Vincent,[2] in a letter on the subject, wrote that whereas it was known in a general way that the position of the burner under the vessel in domestic appliances materially affected the efficiency, investigators had not sufficiently emphasized the fact that the efficiency of gas-burning appliances and cooking vessels of the present design is very low. Only a small part of the heat goes to cook the food immersed in the water. The saving from properly designed and located burners would hardly be a drop in the bucket compared with what might be accomplished by revolutionary changes in the design of household utensils and gas-burning appliances. While the latter might be possible, however, the former presents an almost impossible task. Another saving would be accomplished if the gas supply could be cut off as soon as a cooking process was completed or a vessel removed from the stove.

A general discussion followed, chiefly upon the relation between the gas pressure and the mixture of air and gas, and the possible use of automatic devices for varying the air supply with the pressure, or with the height of flame, such as used in large gas annealing furnaces. Suggestions to this end were made by H. B. Dirks, H. R. Godeke, and H. S. Dickerson.

John Borge[3] said there are a number of burners on the market in which the air shutter is geared to the gas part so that opening part way would admit a certain amount of air and opening further would admit correspondingly more air. Investigations show, however, that there is not much justification in such an elaborate combined valve.

There was also discussion by Victor J. Azbe and others on efficiency, or inefficiency, in larger installations than required in domestic kitchens, such as in bakeries, etc. One instance cited was of a large plant using gas to the value of $200 a day, but at an efficiency of 20 per cent when it should have been 50 per cent with suitable equipment and adjustments.

The next paper, on Locomotive Feedwater Heating, by Thomas C. McBride, described a recently-developed system of feedwater heating for locomotives which makes use of the open type of heater in which the exhaust steam comes in direct contact with the cold feedwater. Mr. McBride said that the practice of feedwater heating for locomotives is followed abroad far more extensively than in this country. In 1918 a single road in France had 61 heaters in service and he had been informed that all the German locomotives turned over to the French under the terms of the armistice had feedwater heaters.

F. N. Speller[4] said that information upon the amount of gas separation in the type of heater described by the author would be of interest as an indication of whether there would be less corrosion in the boiler through the use of an open heater. An open heated of adequate size has a marked effect in retarding corrosion in stationary boilers. A serious objection to closed heaters is the rapid deterioration of the heater itself through the action of corrosive gases in solution. He further referred to heater tests on a western road which showed rapid deterioration.

George M. Basford[5] sent a comment to the effect that while the paper covers certain phases of the subject which have not been well understood and gives new data of value, it is unfortunate that the author confined his treatment to the open type of heater. He had presented his subject in a somewhat less favorable light, in some particulars, than he might have done if he had included results obtained with the closed type of heaters on a number of railroads in this country and abroad.

Grafton Greenough[6] wrote that there is every evidence that the necessity is upon us for the reappearance of the locomotive feedwater heater which, as stated by the author, has lain dormant for over three-quarters of a century. This necessity is twofold: First, the sizes of our most powerful locomotives are seriously restricted by physical conditions and any device which will enable us to obtain greater horsepower without increasing the size of the locomotive boiler should receive attention; and second, there is urgent need for conserving labor, money and the transportation facilities required in producing and delivering coal. The locomotive feedwater heater is a practical agency whereby the size of the locomotive boiler may be reduced and a saving in fuel effected. He predicted that before long it would be regarded as an established device in common with means for superheating and compounding, needful to bring about greater efficiency and economy in the locomotive engine.

The final paper of the session, on the Separation of Dissolved Gases from Water, by J. R. McDermet, awakened a great deal of interest and elicited considerable discussion. Valuable data were given, based on extended experiments leading to the prac-

---

[12] Vice-President, American Blower Co., Detroit, Mich. Mem.Am.Soc. M.E.

[1] Pres., W. N. Best, Inc., New York. Mem. Am. Soc. M. E.

[2] Engineer, Syracuse Lighting Co., Syracuse, N. Y. Mem. Am. Soc. M. E.

[3] Pres. Borge Incinerator Corp., New York City. Assoc-Mem.AmSoc.M.E.

[4] Metallurgical Engineer, National Tube Co., Pittsburgh, Pa.

[5] Pres. Loco. Feed Water Heater Co., New York. Mem. Am. Soc. M. E.

[6] Vice-Pres. in Charge, Baldwin Loco. Wks., Philadelphia.

tical development of the process originated by W. S. Elliott of Pittsburgh. Fundamentally it consists of the rapid injection of heated water into a region of vacuo, and an explosive boiling of it at the expense of the heat of the liquid, with a simultaneous recovery of the heat liberated by a heat interchanger or condenser cooled by the incoming water, preliminary to its heating.

F. N. Speller, in a written discussion, said that the oxygen content of natural water varies from 5 to 10 cc. per liter, according to seasonal temperature. It is desirable to remove dissolved gases as far as possible in an open heater. Quoting the performance of three open heaters in different plants, he said that one heater operating at a temperature of 170 deg. fahr. left in the water an average of 2.55 cc. per liter; another at 204 deg. an average of 0.75 cc. per liter; and the third at 209 deg., 0.70 cc. per liter.

Experience indicates, however, that to prevent corrosion the feedwater used with steel economizers should carry less than 0.20 cc. per liter. Experimental work done by his company and by Dr. W. H. Walker of the Mass. Inst. of Technology indicates that open heaters as usually operated will not reduce the oxygen low enough to stop corrosion. The residual oxygen, after passing through a properly vented open heater, may be reduced below the danger point by further mechanical deaeration, such as passing the water over baffles at about the boiling point in a separate chamber at lower pressure, or by injecting the superheated water into a low-pressure chamber with a condenser in series, as described by Mr. McDermet; or the residual oxygen passing through the heater may be quickly and completely removed by chemical treatment, or a combination of both systems as most convenient. His company, he said, had used the latter principle for five years. It is based on passing the heated water under pressure through a large mass of expanded steel scrap, which he termed "deactivating" the water in distinction to mechanical deaeration.

C. M. Garland[7] wrote that with coal at $6 a ton there are few plants that cannot afford to install the most efficient boiler-room equipment obtainable. This means the installation of economizers. The economizer, however, has not yet reached the stage of development which might be expected, due mainly to the corrosive action of dissolved gases in water. This action has made it necessary to use cast-iron tubes, which must be of large diameter and for high pressures of heavy weight, making the economizer bulky, clumsy and to a large extent impractical.

If the author's investigations and apparatus lead ultimately to the elimination of corrosion in economizer tubes, he will have eliminated one of the most difficult problems in economizer design. Steel-tube economizers can be designed to occupy about one-eighth the space allotted to economizer equipment and will greatly reduce the cost of such installations.

Geo. H. Gibson,[8] in a written communication, said that while the author had credited the method described to W. S. Elliott, it had been pointed out by Wm. H. Walker, in a paper before the Iron and Steel Institute in 1909, that pitting might be entirely avoided by removing air from the feedwater before its introduction into the boiler and that this might best be done by the employment of an open feedwater heater connected to the dry-vacuum pump of a condenser. Also he referred to a similar proposal for the elimination of corrosion in the famous 350-mile Coolgardie pipe line for the Goldfields Water Supply, of Perth, Western Australia, in 1909.

Mr. Gibson contended that effective separation of air can be effected without the complication of vacuum appliances and quoted results obtained by heating water in an open feedwater heater. Under atmospheric pressure the oxygen content has been reduced slightly below 0.2 cc. per liter with the water at the outlet at 210 deg. fahr. It was found essential that the heater outlet temperature be near 212 deg., the oxygen content increasing rapidly at lower temperatures. The maintenance of high temperature in a heater operating under atmospheric pressure requires careful attention to water distribution and to venting.

R. N. Ehrhart,[9] in reply to Mr. Gibson, with regard to the utility of the open heater in preventing corrosion, said that both the author and Mr. Speller had realized the necessity of taking out the oxygen, which the open heater will not do. Some companies have attempted to check corrosion by raising the feed temperatures, say, from 130 to 140 deg. to 210 deg., but the consensus of opinion is that this will not produce the results and that air-extraction apparatus is absolutely essential.

E. H. Tenney[10] pleaded guilty to being one of those who had raised feedwater temperatures and said that there had since been no indication of corrosive action in the economizer. In the Mississippi Valley, where his company's plants are located, the water is highly impregnated with dissolved organic matter, which gives another important problem to be dealt with in addition to that of dissolved gases. This is a troublesome subject which he believed could well be taken up for consideration by the Society.

---

[7]Manager Power Dept., Allen & Garcia Co., Chicago, Ill. Mem. Am. Soc. M. E.

[8]Consulting Engineer, Geo. H. Gibson Co., New York. Mem. Am. Soc. M. E.

[9]Elliott Co., Jeannette, Pa. Mem. Am. Soc. M. E.

[10]Chief Engineer of Power Plants, Union Electric Light & Power Co., St. Louis, Mo. Mem. Am. Soc. M. E.

Members Enjoy Oil Field Visit

THE Mid-Continent Section of the A. S. M. E. and the Oklahoma Section of the American Chemical Society held a joint meeting at Tulsa on May 28 and 29, the occasion being noteworthy as the first joint meeting of a chemical and an engineering society.

Following the St. Louis meeting, about 50 members of the A. S. M. E. left for Tulsa, arriving there Friday morning. They were conducted to the Hotel Tulsa by the Local Section to join them at breakfast at the hotel. Mayor Evans delivered the "keys of the city with all the ceremonies," and promised the visitors that they would either leave the city millionaires or "broke." President Miller responded in his usual gracious manner.

The first part of the morning was spent in riding around the beautiful, well-laid-out city of attractive homes and imposing office buildings. At 11 o'clock the local members with their guests gathered at the Cosden Refinery, where, under the guidance of F. E. Holsten, manufacturing superintendent, and W. H. Pape, mechanical superintendent, the intricacies of the $20,000,000 refinery were explained. The ingenious devices installed to promote the safety of operation for the employees and the various processes of distillation and filtration were gone over thoroughly The plant has a capacity of about 25,000 barrels per day.

Luncheon was served at the refinery of the Texas Company. Mr. W. K. Holmes, superintendent of the refinery, conducted the party through the spotlessly clean plant which attracted very many favorable comments.

A short business session held in the City Hall auditorium was followed by a professional session, at which the following papers were presented:

THE PREPARATION OF MOTOR GASOLINE FROM HEAVIER HYDROCARBONS, Prof. Fred W. Padgett
MODERN WATER PURIFICATION, W. R. Holway
REFINING OF CRUDE MINERAL OILS AND THE ACTION OF ABSORPTIVE CLAYS ON SAME, F. C. Thiele
FLOW OF FLUIDS THROUGH PIPE LINES AND THE EFFECT OF PIPE-LINE FITTINGS, D. E. Foster
SOME INVESTIGATIONS IN BRIQUETTING OF OKLAHOMA BITUMINOUS COAL, Prof. James C. Davis
MID-CONTINENT GASOLINE, Dr. Chas. K. Francis
COAL VS. OIL COST PERFORMANCE CHART, L. C. Lichty

Professor Padgett's paper is presented on another page of this issue, and the other papers will receive consideration in later issues of MECHANICAL ENGINEERING.

SECTION OF OIL FIELDS SOUTHWEST OF TULSA

A banquet was given at the Hotel Tulsa in the evening, Louis Bendit, the dean of engineers in Tulsa, serving as toastmaster. Frank Greer gave a rapid-fire sketch of the remarkable development and marvelous resources of Tulsa, the Magic City, and Oklahoma, the Billion-dollar State. President Miller spoke of the development of coöperation among engineers and of the problems of relation between employer and employee, emphasizing the fact that there must be correct relations for proper production. Dean P. F. Walker, of the University of Kansas, presented the report of the Mid-Continent Section Research Committee which will be abstracted in the August issue of MECHANICAL ENGINEERING. Secretary Rice spoke on the subject of the engineer and his citizenship responsibility and laid out the broad lines on which the activities of the engineer must be organized.

On the following day the party was organized early for a 60-mile automobile trip to the casing-head gasoline plant of the Gypsy Oil Company, crude-oil pumping stations, and the Glenpool oil fields. Mr. H. P. Porter, chairman of the Mid-Continent Section and superintendent of the Gypsy casing-head plant, revealed the mystery of making gasoline in his plant. A most interesting instance of the complete utilization of heat energy was afforded at this plant. After the high-pressure gas has passed the usual condenser and had the normal amount of liquid removed, it is led to a cross-compound engine where it serves as an expansive vapor in the same manner as steam is commonly employed. In this expansion the gas is reduced to a very low temperature, this action being made cumulative in a counterflow system of pipes whereby it is made to refrigerate itself on the way to the engine and in this way extracts from itself an amount of high-gravity gasoline which could not have been recovered in the ordinary high-pressure condenser using water as the cooling system.

A specially arranged feature of the day was the shooting of an oil well. The party watching at a respectful distance saw the 80 quarts of nitroglycerine poured carefully into the tube and lowered 2200 ft. to the bottom of the well. They waited while the casing was being withdrawn but only a few venturesome spirits stayed on, in spite of a foreboding storm and the approaching train time, to see the final shot. Those who did stay witnessed the remarkable spectacle of a fountain of oil mounting 60 ft. above the top of the derrick—but missed their train.

The entire meeting and program of excursions was a brilliant success and every detail of arrangement was worked out very carefully by Messrs. H. P. Porter, J. H. McEwen, D. E. Foster and Earle A. Clark, the officers of the Mid-Continent Section, to all of whom the thanks of the Society are due.

OIL REFINERIES AND STORAGE TANKS OF WEST TULSA. ARKANSAS RIVER IN DISTANCE

Motor Gasoline from Heavier Hydrocarbons

Particulars Regarding Its Preparation by Various Cracking Processes, Together with a Discussion of the Theory of Cracking and Notes on the Present Status of the Industry

By FRED W. PADGETT,[1] NORMAN, OKLAHOMA

The following paper is one of the group prepared by the Mid-Continent Section of the A.S.M.E. for the Tulsa, Okla., meeting held immediately after the Spring Meeting of the Society at St. Louis, and which was attended by a good-sized delegation of those who were present at the latter meeting. It is mainly concerned with those methods known as "cracking" processes which, when applied to the heavier hydrocarbons present in petroleum, produce mixtures within the range of motor fuel. It has as its objects the discussion of the theory of cracking, the description of standard processes, and the consideration of the present status of the industry. It will be found a convenient and valuable summary of the various processes, particularly useful for reference purposes.

THE growing importance of the internal-combustion engine during the past decade has brought with it the attendant problem of fuel supply. While the production of motor fuel in the past has been ample, the data indicate that in the near future we shall be faced with the problem of augmenting the supply, or see a depressing effect upon the automobile industry on account of shortage. The Bureau of Mines in a recent report on refining statistics shows that the gasoline production in 1919 increased 10 per cent over 1918. On the other hand, the number of automobiles registered increased 22 per cent during the same period and the increase of 1920 will be of like order. The question therefore presents itself as to how it will be possible to meet the future demand for motor fuel even though gasoline stocks were increased during the past year. The problem is not now a serious one, but may become so in a very few years.

There are several sources from which additional supplies of motor fuel may be expected. Benzol and toluol from by-product coke-oven plants may be blended with gasoline to give a very satisfactory product, while industrial alcohol is a product to fall back on, if necessary. Crude oil may also be derived from such kerogenous substances as oil shale and there are enormous deposits of the raw starting material in various parts of the country, expecially in Colorado, Wyoming, and Utah, from which the crude oil may be extracted by low-temperature carbonization or a combination of this with ultimate high-temperature effect in the presence of steam to recover the by-product ammonia.

Petroleum consists essentially of a mixture of hydrocarbons which are in the main totally miscible with one another. Organic nitrogen and sulphur compounds are also present in varying amounts and occasionally oxygen compounds, as well as water and inorganic material in disperse form. When this complex of naturally occurring hydrocarbons is treated by dry distillation at atmospheric pressure, the hydrocarbons of lowest boiling point are vaporized first and come into the condenser followed by those of higher boiling point as the temperature rises. Varying degrees of fractionation will obtain depending upon the design of still and method of operation. From the point where gases first appear at the condenser outlet until the temperature in the still reaches approximately 625 deg. fahr., the products secured are in the main natural—that is, they exist in the crude oil as such. Above this temperature, however, especially if the distillation is carried out slowly, what is known as "cracking" takes place and a distillate is secured, which upon redistillation will yield more gasoline and kerosene, their quality, however, in most cases, not being comparable with that of the natural products.

If instead of carrying out the distillation above the 625 point at atmospheric pressure in an ordinary still, one of special design is substituted, and if the operation is conducted at a pressure varying from 50 lb. to 150 lb., profound decomposition or cracking occurs and a yield of gasoline of 15 per cent or more may be obtained, based on the original charge of residue, upon fractionating the pressure distillate secured. The residue remaining, and the pressure distillate which has thus been freed from gasoline, may again be subjected to the process and a further yield of gasoline secured, this being less than in the first case and decreasing upon subsequent treatments.

This process of cracking is a special application of the well-known phenomenon which occurs when organic compounds are heated to a high temperature, decomposition taking place and the molecule being broken down into compounds of lower molecular weight, even with the formation of the elements carbon and hydrogen.

Again, if a sample of the same residual oil be placed in a vertical still having a fractionating column or "tower" interposed between the still and the condenser, and the distillation is carried out at atmospheric pressure, with stirring, in the presence of anhydrous aluminum chloride, the latter acts as a catalyst to cause the decomposition of the oil into gasoline, giving a yield of 15 per cent or more. This process is an illustration of the fact that chemical compounds, working at atmospheric pressure, may effect a result similar to pressure distillation.

Commercial Processes for the Production of Gasoline from Heavier Hydrocarbons

The various processes for producing motor fuel from heavier hydrocarbons may be roughly classified as follows:

1 *The Pressure Still.* A "two-phase" cracking system. Examples are the Burton and Coast processes.

2 *The Pipe Still.* Generally a "single-phase" cracking system. Examples are the Greenstreet, Hall, and Rittman processes.

3 *The Use of Catalytic Agents at Atmospheric Pressure.* This may include reaction both in the single-phase and the two-phase systems. An example is the aluminum chloride process, which is likely two-phase to some extent.

4 *Combinations and Modifications of Two or More of the Above Methods.* The cracking may be in either single-phase or two-phase systems. Examples are the Dubbs, Jenkins, and Bacon processes.

5 *Processes Involving Principles not Included Under the Above Four Headings, but Which May Involve Similar Apparatus or the Use of Pressure.* These methods may have either single-phase or two-phase cracking systems. Examples are the proposed processes of Cherry,[2] Coast,[3] Ellis,[4] and many other processes equally unique. In the first a bipolar high-voltage, oscillating, silent electric discharge is thrown across the vapors; in the second, hot gases are passed through the oil or into contact with oil spray; and in the third, air is supplied to the cracking chamber where, by combustion with a portion of the oil, heat necessary for the cracking of the remainder is generated.

During the past eight years numerous patents involving almost every conceivable form of apparatus have been granted for the purpose of securing hydrocarbons within the gasoline range from those of higher boiling point.[5] Many of these patents seek to obviate the trouble incident to coke deposition, while others have the object in view of producing a gasoline which is comparable

[1] Assistant Professor of Chemistry, University of Oklahoma.

Presented at a meeting of the Mid-Continent Section, Tulsa, Okla., May 28 and 29, 1920.

[2] U. S. Pat. 1,229,886, Jan. 12, 1917, and 1,327,023, Jan. 6, 1920.

[3] U. S. Pat. 1,252,401, Jan. 8, 1918, and Cosden-Coast, 1,261,215, Apr. 2, 1918.

[4] U. S. Pat. 1,295,825, Feb. 25, 1919.

[5] Some of the principles involved are as follows: The use of molten metal as a cracking agent; oil may be sprayed against an electrically heated plate within an autoclave; a perforated basket charged with metallic turnings may be disposed in a furnace; oil vapors may be subjected to progressively increasing and then progressively decreasing temperatures; superheated steam; various methods utilizing electric discharge across vapors; emulsified oil as starting material; etc., etc.

in quality with the natural product. Still others are along entirely new lines.

As early as 1865 James Young, the Scotch industrial chemist, secured a patent for the production of illuminating oil by means of pressure at about 20 lb. per sq. in.

The Pintsch gas process for the production of illuminating gas from gas oil dates back to the seventies in its commercial applications in the United States. As usually carried out at atmospheric pressure, the oil is passed by gravity into cast-iron retorts heated to bright redness. In the upper chamber of the retort oil is vaporized, while in the lower one cracking takes place. The vapors then traverse a tar seal, condenser, purifier, and meter, and are stored in a gas holder at a pressure near that of the atmosphere. The gas is finally compressed to 12 or 14 atmospheres in heavy welded tanks ready for delivery. One gallon of gas oil will produce from 60 to 75 cu. ft. of gas and when the product is compressed at the last stage a liquid known as "Pintsch gas drips" collects to the amount of about 2 or 2½ gal. per 1000 ft. of gas compressed. This liquid, while quite volatile, is very unsaturated and entirely unsuitable as motor fuel.

Benton's Apparatus for the production of illuminating oils from residual oils was patented in 1886 but was never used commercially. A pipe coil within a furnace is heated to a suitable temperature while the oil is forced through at a pressure of 285 lb. per sq. in. or more. The products of the reaction are released into a vapor chamber, which in turn is in communication with a condenser. At the inlet end of the coil is placed a safety valve and at the outlet a stop-cock for regulating the pressure on the coil.

In 1890 a patent was granted *Dewar and Redwood* for an apparatus which differed from that of Benton, to be used in cracking Russian residual oil to illuminating oil, but was never applied commercially because of the introduction of the starting material as fuel and its subsequent rise in price. A retort disposed in a furnace has one end in communication with a dome, the latter also being connected to a condenser. Safety valve, pressure gage, charging line and receiver are also provided, and the condenser and receiver are held under pressure. It is proposed to fill the retort partially, to distill under pressure and to collect the distillate in the receiver. Dewar and Redwood do not state what pressure gives the best results.

The Burton Process. Burton's first patent was granted in 1913 and the process is extensively used at the present time by the various Standard companies. In 1918 it was estimated that 10 per cent of the gasoline produced was by cracking, a large proportion of this being through the Burton still. The development of this process marks one of the milestones in the history of petroleum refining and its originator merits the distinction of being the first to demonstrate that pressure distillation could be done safely and practically on a large scale. In addition, Burton realized the limitations of the type of apparatus and did not attempt, in the original design, to make the operation continuous.

The original claims of Burton consisted in the distillation of petroleum under a pressure of 4 to 5 atmospheres and a temperature of 650 to 850 deg. fahr., maintaining the pressure upon the volatile products until they had traversed the condenser.

The standard Burton apparatus includes a still of 200 bbl. capacity or more, of conventional shape, so constructed that high pressures may be used. Beyond the condenser is located a safety valve which prevents the pressure from rising above a desired maximum and permits the escape of the permanent gases. Next in line is a valve where the pressure upon the distillate is released before it enters the run tank.

Modifications of the original Burton process call for introduction of the oil in the vapor line,[6] amounting to semi-continuous operation, the use of false bottoms[7] upon which the main portion of the carbon collects, and lastly a still containing internal flues.[8]

The Design and Operation of Pressure Stills. At the temperature at which the pressure still operates steel begins to decrease in tensile strength. It is therefore evident that a fundamentally important consideration lies in the material and method of construction of the stills. As an outgrowth of this need there are now firms which specialize in the construction of stills for severe usage. The walls of the stills are ½ in. to ⅞ in. thick and hammer-welded, this method of construction being claimed as superior to both riveting and to acetylene or electric welding for the purpose in view. In the operation of pressure stills the operator has before him thermometers and pressure gages, which inform him of the conditions prevailing within the various units under his control.[9] In the operation of some pressure stills using gas oil as the starting material, the distillation is continued at the average rate of 1 to 2 per cent an hour and the run is completed in 48 hours, giving a yield of 35 per cent of 450 deg. fahr. end-point gasoline. During distillation the bottom of the still is watched and if "hot spots" develop due to superheating from deposited carbon, close surveillance is maintained in order to determine if it will be necessary to close down the still before the run is completed. After each run the deposited carbon is completely removed from the still before recharging.

The Greenstreet, Hall and Rittman Processes. These processes involve cracking mainly in the vapor phase. By the Greenstreet method[10] a mixture of oil vapors and steam is passed through a coil of pipe which is heated, the products next being permitted to expand in drums of considerable size. The pressure is released at a point between the expanding drums and the condenser. The Hall process[11] in a broad way resembles that of Greenstreet but has the fundamental difference in that steam is not used and the pressure is released as the products leave the coils and enter the expanding drums. In the Rittman process[12] the cracking takes place in an upright tube containing a rod and chain, the latter being thrown against the sides of the tube when the former is revolved. The oil is fed into the tube at the top while the vapors are taken off separately from the tar pot at the bottom. All of these processes include the use of pressure.

The Aluminum Chloride Process.[13] The most conspicuous developments under this method have been carried out by McAfee of the Gulf Refining Co.[14] The oil is heated and stirred in a still in the presence of anhydrous aluminum chloride or other anhydrous salt of aluminum. Before treatment the oil must be freed from water and a quantity of the catalyst equal to a maximum of 8 per cent by weight of the charge is added before the distillation is begun. Fractionating towers are interposed between the still and the condenser so that the higher-boiling vapors may be returned to the still along with aluminum chloride which has been vaporized and carried out. The distillation is continued slowly at a temperature of 500 to 550 deg. fahr. over a period of 24 to 48 hours. By this method a yield of gasoline of 15 per cent or more may be obtained from residual oils.

Very interesting in connection with this process is the effect upon the residue remaining in the still and the character of the distillate secured. At the end of the distillation it is found that the aluminum chloride is in mechanical combination with granular coke which is easily removed, and that a heavy oil free from asphalt, and with its viscosity in no way impaired, may be separated from the coke and then utilized for the production of high-grade lubricating oils, the recovery of paraffin wax, or the manufacture of petroleum. The distillate secured by aluminum chloride treatment is water white and possesses a pleasant odor, and in order to secure the finished gasoline it is only necessary to wash the "rerun" distillate with dilute alkali and water.

By the action of anhydrous aluminum chloride on residual petroleum, sulphur compounds are destroyed and possibly nitrogen and oxygen compounds such as naphthenic acids as well.

The one difficulty suggesting itself as being inherent in this

[6] U. S. Pat. 1,199,464, Sept. 26, 1916.

[7] Humphreys patents 1,122,002 and 1,122,003, Dec. 22, 1914, and 1,119,700, Dec. 1, 1914.

[8] Clark patents 1,119,496, Dec. 1, 1914, 1,129,024, Feb. 16, 1915, and 1,132,163, March 16, 1915.

[9] Liquid meters are sometimes placed on the run lines.

[10] See Petroleum Age, 6 (1919), 66.

[11] See Lomax, Jour. Inst. Pet. Tech., 3 (1916), 36.

[12] See Bureau of Mines Bulletin 114 and Technical Paper 161.

[13] See Jour. Ind. Eng. Chem. 7 (1915), 737.

[14] Ibid.

process is that of recovering the aluminum chloride, or of manufacturing it cheaply. McAfee has patented the two following methods for the recovery of the catalyst:

By the first method the aluminum chloride present in the coke is dissolved in water. The solution is then evaporated and heated moderately, when the hydrated salt is broken up into aluminum and hydrochloric acid. The alumina, when mixed with carbon and calcined in the presence of dry hydrochloric-acid gas, reacts to form aluminum chloride, hydrogen, and oxides of carbon.

By the second method the residual coke is heated in an atmosphere of chlorine, when the anhydrous salt is volatilized and carried away by the chlorine vapors.

Finally, it is of interest to introduce one of McAfee's tables on the treatment of 34 deg. Baumé Oklahoma crude petroleum, showing the comparison of the aluminum chloride process with that of the customary method.

	Per Cent of Crude Oil:	
	$AlCl_3$ Process	Usual Process
Gasoline	34.82	12.50
Kerosene	29.47	41.00
Gas oil	5.36	35.00
Residual oil	14.07	9.00
Sum of products	83.72	97.50
Loss	16.28	2.50
	100.00	100.00

While the above table is not representative of the actual amount of gasoline procured at the present time from the average Oklahoma crude petroleum, still the data may serve for making comparisons. At this time the average Oklahoma crude is being refined to about 20 per cent of straight-run gasoline and 17 per cent of kerosene.

Other Processes. Three methods which have recently come into prominence because of favorable reports concerning their operations, are those of *Dubbs*, *Jenkins*, and *Bacon*.

The design and operation of the *Dubbs plant* is given in the report of a committee of the Western Refiners' Association to its members. Extracts from this report are quoted as follows: "The plant proper consists of a cracking coil made up of ten lengths of 4-in. extra heavy lap-welded pipe, each 20 ft. in length, jointed on the ends by return bends. This coil of 4-in. pipe is placed horizontally in a furnace in two rows, six of the pipes being in the lower row and four in the upper row. The furnace temperature is maintained at approximately 1540 deg. fahr. The outlet of the 4-in. coil is connected to an expansion chamber which consists of four 20-ft. lengths of 10-in. common extra heavy pipe. These pipes are connected in series by means of return bends so as to form an expansion chamber approximately 80 ft. long. These 10-in. pipes are positioned horizontally in a chamber and are not heated, but insulated on the outside to prevent loss of heat by radiation.

"The raw oil is fed into one end of the 4-in. coil by means of a force pump, and as the oil passes through it is heated to about 820 deg. fahr. and is then discharged from the other end into the 10-in. expansion pipes, which are maintained approximately half full of oil. The vapors are liberated from the oil and pass up through connecting goose necks to a manifold; then to vapor lines leading to a spiral vapor condenser, and finally into a water-cooled condenser. A pressure of about 135 lb. per sq. in. is maintained on the entire apparatus. The unvaporized portion of the oil in the 10-in. coil is continuously drawn off from the end of the last unit."

In regard to the Dubbs process, it should be noted that the cracking takes place in a two-phase system.

The summary at the top of the next column gives the results of a test run of 168 hours' duration.

In the *Jenkins process* an apparatus is used resembling the water-tube boiler. The tubes in the latest installation are 2½ in. outside diameter, and cold-drawn. The furnace is of the vertical baffle type with Dutch oven, no heat coming in direct contact with either the longitudinal or traverse drums. The operation of the process is continuous and the oil is circulated mechanically. The safe limit of operation (with the type of starting material being used) has been found to be when a volume of oil equal to 14 times the changing capacity has been passed into the apparatus. Working under these conditions it is claimed that the still has long life and that the time of cleaning is only five minutes per tube. In closing down after a run the reduction of temperature is accomplished gradually by forcing more charging oil into the apparatus under complete mechanical circulation, thus eliminating undue stresses or strains which might be caused by a sudden temperature drop. Mr. Jenkins contributes the following data in connection with a run of 46 hours, using pressure distillate gas oil[16] from Homer crude as the starting material:

Total oil circulated	17,130 gal.
Overhead pressure distillate	11,600 gal.
Fuel used—48,000 cu. ft. of city gas (natural).	
Products (per cent yield of original starting material):	
Gasoline (118 I.B.P., 460 end point)	24 per cent
Kerosene	29 per cent
Steam still bottoms	14 per cent
Pressure still bottoms (52 vis. Saybolt at 100 deg. fahr. and when treated, 4½ color)	27 per cent
Total loss	6 per cent

The pressure used in the above run varied from 105 to 110 lb. gage; temperature, 700 to 710 deg. fahr.

The *Bacon process* was developed under the direction of Raymond F. Bacon and Benjamin T. Brooks at the Mellon Institute of Industrial Research. As originally designed some difficulties were encountered during operation because of coke deposition on the tubes; but according to the latest information certain improvements have made the process appear very promising. The "cracking" is carried out in a vertical tube 20 ft. in length and 6 in. to 19 in. in diameter, the oil level being maintained at the top of the heated zone and the process operated continuously. The oil inlet and vapor outlet are located at the top of the tube. The lower end of the tube is connected to a drum into which the tar and coke settle and are drawn off from a pipe at the bottom. When operating an apparatus of this type, coke accumulates very slowly on the metal surface in the cracking zone and in addition a large heating surface is exposed to the oil. The pressure specified is from 60 to 300 lb. per sq. in., but preferably 100 lb. The yields of gasoline (56 Bé.) claimed for various oils are as follows:

Oklahoma gas oil (32 Bé.)	45 per cent
Mexican fuel oil (12 Bé.)	50 per cent
California fuel oil (14 Bé.)	47 per cent
Caddo heavy crude (12-14 Bé.)	48 per cent

Deposition of Coke During Cracking. It has already been mentioned that one of the most serious difficulties encountered during "cracking" is the deposition of coke. Unless removed from the walls of the apparatus very soon after its formation, the coke produced becomes very hard and seems to unite with the metal. Superheating (hot spots), consequent softening of the metal and finally "blowing out" may be the result of this condition. A majority of the processes include, among other things, methods of eliminating the coke from the heating surface. Thus the Burton process involves a modification in which false bottoms are used, the Rittman process a revolving rod and chain, the Bacon process vertical heating surface in the presence of liquid, and so on.[17] One patentee specifies the use of steel balls which are passed intermittently through the "cracking" tube.

Total gas oil treated	20,952 gal.
Total uncondensable gas	25,851 cu. ft.
Fuel used[15]—equivalent of 3677 gal. of 14 Bé. fuel oil.	
Products (per cent yield of original oil charged):	
Gasoline (440 end point) (58.59 Bé.)	26.29 per cent
Kerosene (40-41 Bé.)	14.11 per cent
Pressure distillate bottoms (31-32 Bé.)	27.19 per cent
Residuum (13-14 Bé.)	24.71 per cent
Loss	7.70 per cent
	100.00

[15] Consumed during the run.

[16] It should be noted that this starting material has already been once through the process.

[17] In some refineries it is the practice simultaneously to agitate the oil slightly and to scrape the bottom of the still by means of a sweep with chains attached.

(*Continued on page* 426)

ENGINEERING SURVEY

A Review of Progress and Attainment in Mechanical Engineering and Related Fields, as Gathered from Current Technical Periodicals and Other Sources

SUBJECTS OF THIS MONTH'S ABSTRACTS

WIND-TUNNEL STUDIES OF AERODYNAMIC PHENOMENA
MECHANICAL SCREENLESS AIR FILTERS
RASCHIG RINGS IN VALVES
STRESSES CAUSED BY COLD ROLLING
SURFACE COMBUSTION, MIXTURE REGULATION IN
AUTOMATIC MIXTURE PROPORTIONERS FOR SURFACE-COMBUSTION FURNACES
FUSAIN AND COAL DUST
CHANTRAINE METALLURGICAL FURNACES
POLYMULTIPLE FLAME COMBUSTION IN METALLURGICAL FURNACES
OZONE CONCENTRATION IN VENTILATION
INITIAL TEMPERATURE AND PHYSICAL PROPERTIES OF STEEL
OBTURATORS IN INTERNAL-COMBUSTION ENGINES
TURNER-MOORE MOTOR-CAR ENGINE
ACCENTUATED VALVE INCLINATION IN MOTOR-CAR ENGINES
BUREAU OF STANDARDS ALTITUDE TESTING LABORATORY
RATE OF FLAME PROPAGATION, MEASUREMENT OF
VISCOSITY OF LUBRICANTS, A. S. T. M. PROPOSED STANDARD TEST FOR
DIESEL MARINE MACHINERY, TRENDS OF DESIGN
UNIVERSAL JOINT, MECHANICS OF
FLYWHEEL EFFECT, SYNCHRONOUS MOTORS CONNECTED TO RECIPROCATING COMPRESSORS
SCHNEIDER 155-MM. GUN
THRUST BORING IN EARTH
STABILITY OF MOTOR OMNIBUSES

AERONAUTICS

WIND-TUNNEL STUDIES IN AERODYNAMIC PHENOMENA AT HIGH SPEED, F. W. Caldwell and E. N. Fales. A great amount of research and experimental work has been done and fair success obtained in an effort to place airplane and propeller design upon an empirical basis. However, one cannot fail to be impressed by the apparent lack of data available toward establishing flow phenomena upon a rational basis, such that they may be interpreted in terms of the laws of physics.

With this end in view it was the object of the authors to design a wind tunnel differing from the usual type especially in regard to large power and speed of flow, which involves features whose suitability cannot be predicted. After all available information has been secured on full-size and model wind tunnels in various parts of the world, there remains much obscurity about the airflow phenomena. It is the assumption of Dr. George de Bothezat that the type of air flow which establishes itself is governed by the stresses set up in the air passing the aerofoil. The unit stresses increase as the velocity rises, and it is easy to conceive that a given type of flow is possible only so long as the shearing stresses developed in the fluid do not exceed a certain magnitude, which depends on the value of the viscosity coefficient.

Experimental investigation of the flow has heretofore been rather unsuccessful because of lack of adequate methods. The writers laid out the design of the McCook Field wind tunnel to investigate the scaling effect due to high velocities of propeller aerofoils. During the course of the experiments, however, it was found possible to visualize the air flow by the following method: The velocities of the air flow discovered by the writers offer a solution to one of the fundamental problems of aerodynamics. This problem is the quantitative empirical measurement of the phenomena of fluid dynamics pertaining to flight and air flow. The method described in the report for visualizing air flow depends upon the fact that the moisture in the air condenses as a fog when the temperature is reduced to the dewpoint, provided that there is a solid or liquid nucleus to start the condensation. In the McCook Field wind tunnel the temperature drop is brought about through expansion of the air during acceleration, due to a drop of pressure of 100 in. of water. The relative humidity of the atmosphere can be artificially raised if too low, and the necessary nucleus for condensation is provided by the model tested. Flow vortices become readily visible, and the report contains many photographs showing the air flow past an aerofoil under different conditions.

In this connection, attention is called to the paper by the same authors presented at the Spring Meeting of the A. S. M. E., and given in abstract form in MECHANICAL ENGINEERING for April 1920, p. 213 (National Advisory Committee for Aeronautics Report No. 83, 52 pp., 42 figs., *e.l.*)

AIR MACHINERY

German Screenless Air Filters

MECHANICAL SCREENLESS AIR FILTERS, Ernst Preger. There are four ways of filtering air. One is to pass it through a screen so fine that the dust will be kept out. The second way is to pass it through a liquid, which in this case acts as a screen of infinitely fine mesh. The third method is to pass the air through an electrical screen, the mesh of which is constituted by lines of electric force. This is the Cottrell system of dust precipitation, which is very effective under certain conditions. The fourth way is to interpose in the path of the flowing air mechanical obstacles which will not interfere to any very material effect with the flow of air itself, but will cause precipitation or separation of the heavier particles such as dust. A number of devices belonging to this fourth class are described in the present article.

In the air filter of the Balcke Machine Co. of Bochum, Germany, Fig. 1, the air flows between several rows of vertical

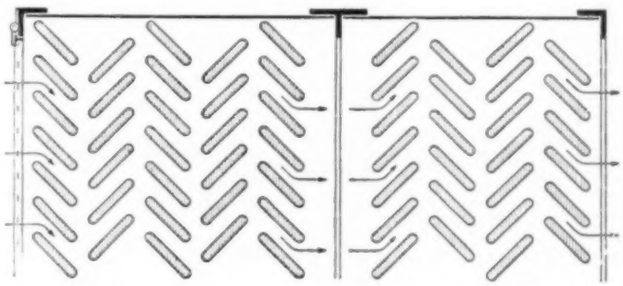


FIG. 1 BALCKE AIR FILTER (SECTION THROUGH THE PLANKS)

wooden planks staggered and located at angle of 45 deg. with respect to each other, as shown in the drawing. Because of the frequent changes of direction the dust particles are projected against the wooden planks and washed off them by the water flowing over their faces. Because of this arrangement, it is necessary to clean the planks. Fig. 2 shows a Balcke cleaner capable of handling 24,000 cu.m. (847,300 cu. ft.) of air per hour.

Water is raised to the top of the cleaner by pump *A* and is distributed over the planks *N* by the trough *B* and hopper *C*. The water accumulates at *D* and may be used for purposes where the presence of dirt in the water is not injurious.

Back of the wet planks *N* are located several rows of dry planks *P*, the purpose of which is to catch the water particles carried off from the wet half of the filter. It has been found in

practice that these planks remain very nearly dry, a good indication that the use of the wet filter causes only an insignificant increase in the humidity of the air. Measurements have shown that with fairly dry entering air there is an increase of humidity of from 3 to 5 per cent, and when the humidity of the entering air is considerable, there is practically no increase of humidity.

Air filters of this type are mainly used for cleaning air employed for purposes of cooling, since there the variation of humidity is of lesser importance than, for example, with air

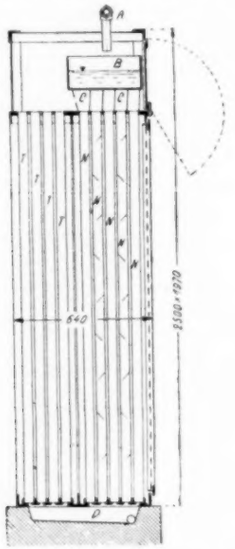


FIG. 2 BALCKE AIR FILTER IN SECTION

compressors. As advantages for this type of filter are claimed the low resistance in the filter, the elimination of filter cleaning and the absence of fire danger from the accumulation of dry dust.

The next mechanical air filter described is the Viscin filter of the German Air Filter Construction Co. of Berlin. The active part of the Viscin filter consists of a frame filled with so-called Rachig rings of about 14 mm. (0.56 in.) height and the same diameter. These rings are wetted with a liquid called viscinol, which is

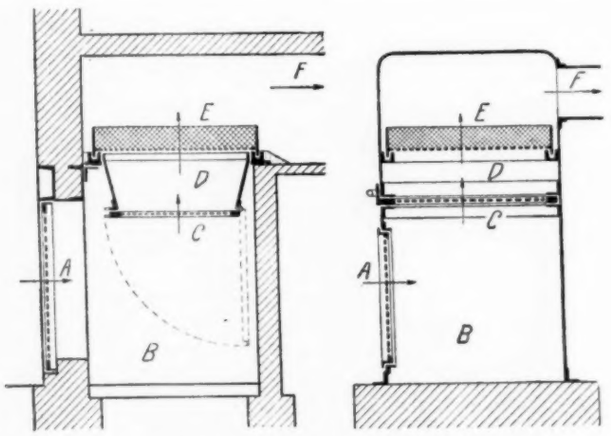


FIG. 3 MOELLER AIR FILTER

claimed to be very sticky and little subject to deterioration. This type is not described in detail as its operation is evidently dependent on the use of a particular liquid used in wetting the rings.

The Moeller filter, Fig. 3 (K. & Th. Moeller, Brackwede, Germany), consists also of a frame filled with Rachig rings, but in this instance the rings are not wetted. The air enters through a perforated sheet-iron wall *A*, its velocity in the chamber *B* is considerably reduced and there occurs further a sharp change in direction of flow which causes the precipitation of the larger particles of dust. The medium-size particles of dust are held back by the screen *C*. *E* is a horizontally located container filled with Rachig rings which hold back the finest particles of dust. The air comes out at *F*. Because of the three-stage method of separating the dust, namely, at *D*, *C* and *E*, a high degree of filtering is obtained notwithstanding the fact that no wetting of rings is resorted to. On the other hand, the dimensions of the air filter have to be made larger than in wet filters. Also the filters have to be cleaned every two or three months.

Strictly speaking, the Moeller filter does not belong to the class of screenless filters as a screen is used. It performs, however, secondary functions. (Stofflose Luftfilter, *Werkstatts Technik*, vol. 14, no. 3, Feb. 1, 1920, pp. 71-73, 16 figs., *d*)

BUREAU OF STANDARDS

A NOTE ON STRESSES CAUSED BY COLD ROLLING, H. M. Howe and E. C. Groesbeck. The experimental data here presented show that a given amount of reduction by rolling causes less residual stress in the metal rolled if it is brought about by a large number of light drafts than if by a smaller number of heavy ones. This is shown by means of the curvature induced in each of a pair of superposed strips when they are simultaneously reduced in thickness by rolling, with varying reductions.

The result is attributed to the greater skin friction between the metal rolled and the face of the rolls with heavy than with light reductions. Because of this greater skin friction more of the reduction occurs through the backward forcing of the deeper-seated layers, and less through the elongation of the surface of the metal in contact with the rolls. (Abstract of *Technologic Paper of the Bureau of Standards* No. 163, *e*)

FUELS AND FIRING

Mixture Regulation in Surface-Combustion Furnaces

SURFACE COMBUSTION, A. E. Blake. An extensive paper discussing the principles and describing the application of surface combustion. Only some passages of particular interest can be abstracted here owing to lack of space.

The factor of the highest importance in the perfected surface-

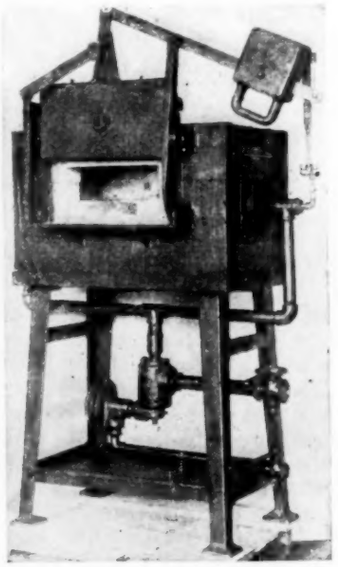


FIG. 4 SURFACE-COMBUSTION FURNACE WITH LOW-PRESSURE AUTOMATIC PROPORTIONER

combustion process is the production of perfect mixture or of any desired mixture to produce essential conditions within furnaces. There are several types of such automatic proportioning or mixing devices. Fig. 4 shows one type attached to the manifold upon the furnace. It is called the low-pressure system. In this case air is supplied at a maximum pressure of about 1 lb.

per sq. in. Two cocks are provided and the air supply is governed by the upper of these cocks. The air from the chamber passes through a venturi tube to a manifold supplying the burners. Within the throat of the tube is located an adjustable nozzle and the location of this nozzle determines the proportion of air and gas in the mixture. In operation air creates suction upon the nozzle. The gas comes from a governor, the function of which is to deliver the gas at constant atmospheric pressure at all times regardless of the rate of flow. There is a diaphragm which is moved by atmospheric pressure and causes the opening of the gas entry port. Changing the air supply automatically changes the gas supply and during operation the gas cock is never touched.

In the original article another type of automatic proportioner, the so-called high-pressure type, is shown and described. No decisive steps have been taken as yet in the matter of preheating air and gas either separately or combined. This is partly due to the fact that the highest temperatures which furnaces will withstand can be secured easily without preheating, and also to the fear that preheating may cause premature ignition.

The presentation of the paper was followed by an interesting discussion which cannot be abstracted for lack of space. (Advance copy of a chapter in a book, "American Fuels," by R. F. Bacon and W. A. Hamor (McGraw-Hill) presented before the Engineers' Society of Western Pennsylvania. Abstracted from the *Proceedings of the Engineers' Society of Western Pennsylvania*, vol. 36, no. 3, April, 1920, pp. 145-174, 27 figs. in the original paper, and discussion pp. 175-204, *g*)

COAL DUST AND FUSAIN, F. S. Sinnatt, H. Stern and F. Bayley. Investigation of the composition of fusain and the amount present in the dust produced during the working of the coal at the colliery, with particular reference to Lancashire coal fields.

The investigation is being continued with a special object of determining, among other things, the properties of the fusain with special reference to the temperature at which it will ignite and the influence of fusain upon the general properties of the coal or coal dust in which it occurs.

Fusain is a jet-black powder which causes a black and dirty smudge on the skin. It has a needle-like structure different from particles of bituminous coals of the same degree of fineness. It ignites with considerable ease at a low temperature and continues to smolder at a dull red heat. It may smolder for a long time without the production of flame or the evolution of compounds having an odor, which adds to the dangers associated with the composition of fusain, as practically no indication is afforded of the substance being on fire.

The following experiments indicate the manner in which fusain burns: A briquet measuring 4 in. by 4 in. by 9 in. was made by mixing fusain with water; it was dried at a temperature of about 105 deg. cent. and allowed to stand for one week. The briquet was then placed on a stone slab and the tip of one corner heated to redness by means of an ordinary match. The briquet was allowed to remain undisturbed, and in about an hour the whole of it was consumed without the production of smoke or flame; there was no evidence of combustion except a faint, pleasant aromatic odor resembling that of pitch pine. The mass smolders internally, for when the surface is removed a glowing dull-red zone is exposed. The residual substance, in certain experiments, was a finely powdered coke—in fact, it appeared as if the volatile matter only had been consumed; in others the residual substance was the ash. A briquet of similar dimensions containing 50 per cent of fusain and 50 per cent coal acted in the same manner, and again practically no odor or smoke was produced.

When fusain is carbonized a coke is produced having an appearance practically identical with that of the original substance. This coke is jet black and is quite deficient in caking power.

It is of interest to note that dust from a dust collector of which 95 per cent by weight would pass through a sieve of 1/90 mesh was found to contain about 49 per cent fusain. (*Lancashire and Cheshire Coal Research Assn. Bulletin* No. 5, 1920, 19 figs., *ep*)

FURNACES

Polymultiple Flame Combustion in Metallurgical Furnaces

CHANTRAINE METALLURGICAL FURNACES. Description of a new type of furnace in which combustion is carried on by means of a large number of separate jets of flame.

In conventional metallurgical furnaces the firing is effected by means of flame obtained through a simultaneous admission of the air and gas. With these systems the high temperatures needed for the metallurgical process can be maintained only in certain definite sections of the furnace, which, because of this, has a very variable régime throughout the combustion chamber and this leads to trouble, both as a result of the irregularity of distribution of heat and because of oxidation. It is claimed that the system described in this article, which the author calls "polymultiple flame" combustion, avoids these defects.

The characteristic features of the Chantraine method are:

1 There is a reservoir of hot air, usually produced by making the roof of the combustion chamber double and providing for an interspace through which pass the conduits leading the air to the combustion chamber from the hot-air regenerator.

2 A number of orifices are provided in the lower roof of the hot-air reservoir, these orifices acting as tuyeres to admit air to the combustion chamber.

3 A sheet of combustible gas floats under the perforated roof of the combustion chamber; this sheet of gas is fed in slowly and continuously through gas conduits from the gas producers.

4 A continuous apparatus is provided for recuperating the combustion-chamber waste heat and to employ this latter for a preliminary preheating of the secondary air.

The operation of the system is based essentially upon the following: The air under pressure, whether natural or artificial, passes through the multiple tuyeres and then through the sheet of gas slowly and continuously fed to the roof of the combustion chamber; in doing this, the air creates a bundle of flaming darts, a compact bundle directed toward the material to be heated. The products of combustion are exhausted solely by the pressure in the combustion chamber.

The theory of this system of combustion is as follows: If a jet of gas passes into the air, as happens in conventional systems, combustion occurs on the periphery of this jet and this periphery produces heat radiations, the majority of which pass into the air which is diathermanous while the commercial combustible gas is athermanous.

On the other hand, if a jet of air is made to penetrate into the atmosphere of ordinary combustible gas so as to produce the same number of calories per second, the periphery of the jet also emits heat and light radiations and a great majority of the heat radiations go into the air of the jet, preheating it all the more the less air there remains for the oxidation of the gas, which latter is athermanous. As a result of this, the tip of the flame of air in a gas atmosphere is many times hotter than the tip of the flame of gas in an air atmosphere and the combustion even with the low initial temperature is practically perfect with the minimum access of air, while in the opposite process (gas going into an air atmosphere) the excess of air must be very large.

Furthermore, in conventional furnaces the radiation spreads equally over the roof and the side walls as well as over the floor of the furnace and the material located thereon. In polymultiple-flame furnaces the sheet of gas floating against the roof protects it as well as the walls against the radiations from the bottom of the furnace and the melting material. Also since the roof of the furnace is equipped with a number of orifices through which a constant flow of air takes place, the refractory material of the roof is never permitted to attain a temperature high enough to soften it or melt it.

Uniformity of temperature distribution in the furnace is secured because each jet projects on to the part of the flow whereon it projects a certain number of calories.

The analyses of exhaust gases obtained when this system was

employed have given contents of carbon dioxide very closely approaching the theoretical maximum. This fact is explained in the following manner. As the tips of the jets of air are very highly superheated, they consume all the oxygen which they contain during the passage through the fairly stagnant and thick sheet of combustible gas, the temperature of which increases as the flame nears the floor of furnace.

Fig. 5 shows the general construction of the Chantraine furnaces. As regards the temperatures obtainable with this system, it is stated that the temperatures at the tip of the individual jets are close to the theoretical temperature of combustion. Since the jets cannot radiate their heat through the sheet of gas through which the air flows, all the heat is retained and is used to raise the final temperature of combustion.

In ordinary furnaces a certain amount of metal is lost through oxidation. In the Chantraine system the metal is separated from the oxidizing agents by a thick and uninterrupted sheet of neutral gases (products of combustion) the oxygen of which has been completely neutralized during the passage of the flame through a very hot sheet of reducing gases. This oxygen

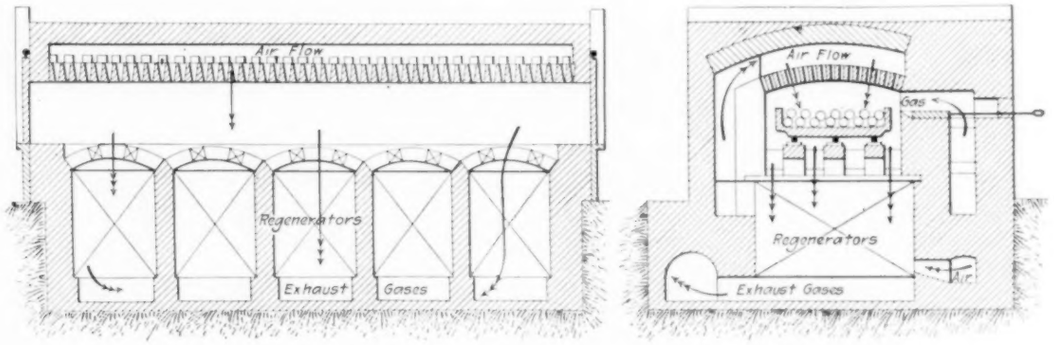


FIG. 5 CHANTRAINE "POLYMULTIPLE FLAME" METALLURGICAL FURNACE

itself having been heated to an exceeding high temperature. Furthermore, the pressure existing in the combustion chamber prevents the possibility of the entrance of outside air. It is claimed that a fuel economy as compared with conventional types of furnaces may be secured as high as 40 per cent, with lower metal losses and lower maintenance costs. This construction is particularly suitable for reheating furnaces, for steel-melting furnaces, etc. (*Le Génie Civil*, vol. 76, no. 14, April 3, 1920, pp. 336-337, 2 figs., *dA*)

HEATING AND VENTILATION

THE SIGNIFICANCE OF ODORLESS CONCENTRATION OF OZONE IN VENTILATION, E. S. Hallett. This paper is essentially a companion to the paper by the author abstracted in the April issue of MECHANICAL ENGINEERING (p. 244).

The author states that chemical methods of determination of ozone cannot be conveniently utilized for ventilation purposes—(1) because the apparatus must be used often under conditions where chemical tests are not available, and (2) because the concentration of ozone for ventilation is too low for such tests. Therefore the odor remains the only indicator of excessive concentration, notwithstanding the fact that only a rough approximation of measurement is thereby made available.

Ozone in ventilation is not a stimulant and its refreshing action and the freedom from languidness are only normal conditions due to freedom from depression resulting from odors and excessive heat. Furthermore, the effects of ozone do not wear off rapidly, and are not psychological merely, as excellent results have been observed in schools where teachers and pupils were unaware of the presence of ozone.

Interesting data are presented concerning the influence of ozone on the degree of susceptibility to influenza. During the epidemic of 1918 the writer accidentally discovered that very few motormen of the street-car service contracted the disease, which was ascribed to the action of ozone emitted by the car controllers.

It was also found that employees in offices having ozone air purification proved to be remarkably immune to influenza. This is explained by the fact that ozone increases the oxyhaemoglobin content of the blood and thereby increases the resistance of the body to all disease. (*Journal of the American Society of Heating and Ventilating Engineers*, vol. 26, no. 4, May 1919, pp. 423-425, *gp*)

HEAT TREATMENT

THE EFFECT OF INITIAL TEMPERATURE UPON THE PHYSICAL PROPERTIES OF STEEL, J. H. Andrew, J. E. Rippon, C. P. Miller, and A. Wragg. Discussion of the effects which variation in initial temperature has upon the position of the resulting transformation point in certain nickel, chromium, and nickel-chromium steels.

The volume change at the normal transformation points as shown by the dilatometer has been found to be composed of two changes working in opposition, namely, allotropic change and change due to the carbide. The latter change in steels of high carbon content is not completed at the ferrite or carbide (SE) line, but continues to a temperature depending on its composition, particularly carbon content, increasing with this. This quantity has been shown to be a measure of the molecular concentration of the carbide in solution, and controls the temperature at which the allotropic transformation takes place.

This variation in the molecular concentration is explained by the assumption that carbide dissociates at and above the temperature of the normal transformation point.

Nickel-chromium steels behave in much the same way as carbon steels, excepting that in the latter the time factor necessary to produce the same changes in the carbide is of a much lower order.

Martensite has been shown to be the product formed when the allotropic change has been depressed by dissociated carbide to a temperature at which the latter is able to exist as such in the alpha iron formed. At the temperature of the normal transformation point martensite is not formed as an intermediate phase between austenite and pearlite.

By tempering austenite in such a way that the carbide becomes partially associated, the allotropic change is able to take place on recooling, forming martensite, thus explaining the phenomenon of secondary hardening.

It has been shown that in the carbon steels experimented with, quenched at 1000 deg. cent., the iron in the product is in the alpha state. In alloy steels gamma iron is present in various proportions, particularly with high carbon content. In extreme cases alpha is entirely absent. (Paper before Iron and Steel Institute, Annual Meeting, May 6-7, 1920, abstracted from advance proof, 82, pp., 71 figs. and 1 plate of photomicrographs, *eA*)

INTERNAL-COMBUSTION ENGINEERING (See also Marine Engineering)

Obturators in Internal-Combustion Engines

OBTURATORS VERSUS PISTON RINGS. Experiences in air-cooled engines on aircraft led in some cases to the replacement of the ordinary piston rings by an obturator, which is essentially the equivalent in metal of the cup leather used for packing hydraulic cylinders. The air-cooled cylinders of rotary engines, it was found, suffered distortion when at work owing to the leading side of the cylinder being more effectually cooled than the trailing side. As a consequence, piston rings often failed to hold the pressure satisfactorily. Any increase in their number would have involved a longer and heavier piston, and the obturator was introduced in consequence. This, as explained in an interesting and valuable paper by Mr. W. Fennell, M. I. E. E., which was read at a recent meeting of the Diesel Engine Users' Association, consisted of a flexible L-shaped ring forced against the cylinder wall by fluid pressure. At the outset the life was short, but improvements made at the works of "Engineering and Arc Lamps" increased the life from 10 hours to 60 hours, and in exceptional cases to 250 hours. Brass was the metal first employed, but a special phosphor bronze is now used. The obturator was placed near the top of the piston, but being flexible and forced by the pressure into close contact with the relatively cool wall of the liner, it did not burn. Nevertheless, it is now considered preferable to fix it some little distance below the piston head. As originally fitted the rings were split similarly to a piston ring, but a lap joint is now used and with this the obturator works well, even if the liner be worn out of truth. In consequence of the satisfactory behavior of these obturators, Mr. Fennell determined to fit one to a three-cylinder Sulzer-Diesel engine rated at 140 hp. The liners of this engine had worn badly, being far from circular and tapering to the extent of 0.1 in. It was impossible under the conditions to obtain new liners, and piston rings failed so rapidly the engine could not be run save at a prohibitive cost. It was decided accordingly to fix the three top rings of the piston and to place an obturator in the fourth groove. After a run of 100 hours without loss or blowing by, the obturator was examined. The wear was less than 1 mil, and the engine was set to work again, without replacing it. This obturator lasted 380 hours and then failed, due to wear at the lap joint. Here the motion was considerable, owing to the taper of the liner. Further experiments showed that even with these badly-worn liners the obturator might be counted on to last 300 hours, which was longer than the piston rings would stand. Further tests, Mr. Fennell stated, are in progress, and they indicate that with the liners in proper condition the life of the obturator should be well over 1000 hours. (*Engineering*, vol. 109, no. 2833, April 16, 1920, pp. 520, editorial, *g*)

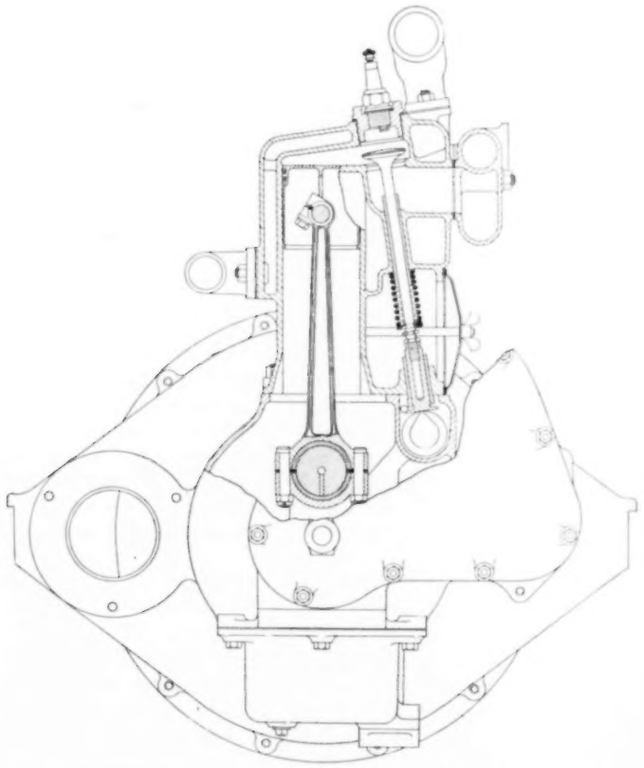


FIG. 6 TURNER-MOORE MOTOR-CAR ENGINE (CROSS-SECTION SHOWING INCLINED VALVES)

Motor-Car Engine with Hollow Crankshaft and Strongly Inclined Valves

TURNER-MOORE MOTOR-CAR ENGINE. Description of the new Turner-Moore 3½ by 5-in. four-cylinder engine having some interesting features. One of these is the hollow crankshaft. It is 2 in. in diameter at all bearings. There are no oil tubes, all of the leads being drilled. The engine also has a tunnel in which are housed a camshaft and bearing points of the tappets. This construction permits the operation of the camshaft and cams in an oil bath.

Fig. 6 shows the valve arrangement with its accentuated inclination of the valves, the purpose of which is to secure better

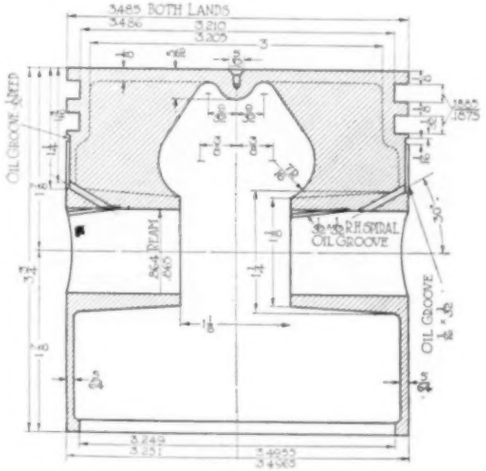


FIG. 7 TURNER-MOORE MOTOR-CAR ENGINE (SECTION SHOWING WEB CONSTRUCTION AND OIL RELIEF IN PISTONS)

scavenging inasmuch as it permits the exhaust gases to be swept off the top of the piston directly into the exhaust passage. The inclination also permits of increased water space around the valve-stem guides and in addition gives a shorter combustion chamber.

On the pressure-feed lubricating system there is a ball check and relief valve at the end of the oil line, the overflow from which lubricates the timing gears. The cylinder walls are lubricated by oil mist thrown from the connecting-rod bearings, and the remaining bearings are taken care of by direct-pressure feed.

The pistons are semi-steel and as shown in Fig. 7 are heavily webbed, the web being split at the center as to avoid distortion due to expansion. The piston has two rings at the top end. Below the lower ring there is an oil groove 1/32 in. deep around the entire piston, and at the point directly above the piston pin there is a slot cut in the side of the piston, the lower end of which is in connection with the drilled lead to the top of the piston-pin bearing. The effect of this is said to be to force oil to

the top of the piston bearing on every up stroke. (*Automotive Industries*, vol. 62, no. 17, Apr. 22, 1920, pp. 946-947, 5 figs., *d*)

Bureau of Standards Altitude Testing Laboratory and Apparatus to Measure Rate of Flame Propagation

BUREAU OF STANDARDS NEW ENGINE-TESTING PLANT, R. S. McBride, Description of the altitude testing laboratory at the Bureau of Standards. The purpose of the laboratory is to test aeronautical engines, reproducing artificially the surrounding conditions under which they have to operate at various altitudes.

During the war period the laboratory was housed in temporary buildings, but a new laboratory has just been completed. This is a substantial brick and concrete building about 50 ft. by 100 ft. The altitude chambers are so designed that conditions can be reproduced in them such as are likely to be encountered at altitudes up to 40,000 ft. These chambers are large enough to take the largest aeroplane engine.

The operation of the altitude laboratory requires a rather complicated system of controls for the engine, the air system and the dynamometers. In the new laboratory all these have been brought nearer together so that a single operator has complete control of the system without moving from his regular position of observation. It is thus possible to quickly adjust conditions for

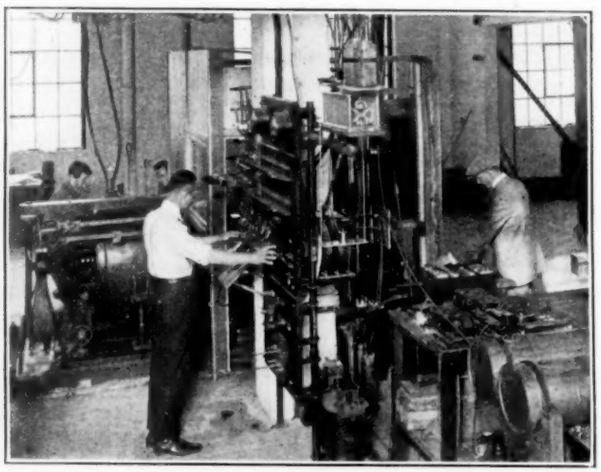


FIG. 8 TESTING A SINGLE-CYLINDER LIBERTY ENGINE FOR RATE OF FLAME TRAVEL

a test, carry through the observations and be ready for a new adjustment of conditions.

Other highly interesting equipment provided includes, for example, the arrangement shown in Fig. 8 to permit the study of the rate of flame propagation within the cylinder of an engine. This has been made possible by a triple spark-plug system which operates roughly as follows: At the time the flame of burning gas-and-air mixture passes over the spark plug the gases are ionized and a reduction in electrical resistance results. This permits the passage of a spark across the gap. The spark plugs are connected to a spark chronograph (which is being adjusted by the operator at the right in Fig. 8) or an oscillograph and the relative time of the passage of the flame past these three points can thus be measured (*American Machinist*, vol. 52, no. 20, May 13, 1920, pp. 1061-1063, 4 figs., *d*)

LABORATORIES (See Internal-Combustion Engineering)

LUBRICATION

PROPOSED STANDARD TEST FOR VISCOSITY OF LUBRICANTS. The test was proposed as tentative in 1919 to the American Society for Testing Materials, but it has not yet been finally adopted.

According to this proposal viscosity shall be determined by means of the Saybolt standard universal viscosimeter described in a general manner and illustrated in the original text.

Viscosity shall be determined at 100 deg. fahr., 130 deg. fahr. or 210 deg. fahr., and for viscosity determinations at the first two temperatures either oil or water may be used as the bath liquid.

The discharge is measured by a standard receiving flask shown in cross-section in the original paper and the time in seconds for the delivery of 60 cc. of oil is the Saybolt viscosity of the oil at the temperature at which the test was made. (*Report of Committee D-2 on Lubricants of the American Society for Testing Materials*, preprint, 5 pp., 2 figs., *gp*)

MACHINE PARTS AND DESIGN (See Internal-Combustion Engineering)

MARINE ENGINEERING

THE GENERAL TREND OF DIESEL MARINE MACHINERY. According to an editorial in *Engineering*, there is at the present time no problem concerning the minds of marine engineers to a greater extent than that of the application of the Diesel oil engine to marine propulsion.

Statistics, as far as they are available, and without any data as to German construction, show that in the field of ships of greater deadweight capacity than 2000 tons considerably more than 150 are on order and in course of construction at the present time and are destined to be fitted with marine Diesel engines.

In the list of countries where this kind of work is done Denmark occupies the first place, the United States of America the second, and Great Britain the third, but it is claimed that the position of Great Britain is rapidly being improved.

A review of the type of engine being constructed goes to show that the simple single-acting 4-stroke-cycle engine is largely preferred today, and of the vessels built only some 16 per cent are to be fitted with engines of the 2-stroke-cycle type. Moreover, almost half of the 2-cycle engined ships are single-screw, whereas 90 per cent of the 4-stroke cycle machinery is of the twin-screw variety. Of all the motor vessels over 80 per cent are fitted with twin screws.

The 2-stroke-cycle engines comprise the opposed-piston types at present exclusively built in Britain, the supercharging port scavenging engine originated in Switzerland and being built now chiefly in Switzerland and Italy, and the valve scavenging engine which is now retained by only one French constructor. In America very few 2-cycle Diesel engines are in the course of construction, and Sweden, Denmark and Holland are solidly in favor of the 4-stroke cycle engine.

In Britain not only is the greatest variety of type evidenced, but also the largest engines are being constructed, the most powerful, the 4-cylinder opposed-piston two-stroke engine of 750 b.hp. per cylinder. The cylinder diameters are 580 mm. and the stroke 1160 mm., and the engine develops at 70 revolutions a total of 3000 b.hp. in the four cylinders. The largest 4-cycle engine being constructed in Britain, and also elsewhere, has cylinder diameters of 740 mm. by a stroke of 1150 mm., and runs at 115 r.p.m., developing over 3500 b.hp. in eight cylinders. The 2-cycle engines are of four and six cylinders—generally of four cylinders—and the 4-cycle engines have six cylinders, with a few exceptions where eight cylinders are employed to give the desired high power.

The British policy of trying out all types of engine is certain to lead in the end to a very favorable position, and is a very bold one and to be commended in view of the leeway which had to be made up and the lead unquestionably held by the earlier constructors of 4-cycle engines. The unfortunate and unlikely event of failure with any of the newer types cannot now, in view of the varied and long experience already piled up to the good, be taken as evidence sufficient to condemn this prime mover in respect of its suitability for marine work. (*Engineering*, vol. 109, no. 2836, May 7, 1920, pp. 617-618, editorial, *g*)

MECHANICS (See also Transportation)

The Mechanics of the Universal Joint

FORCES ACTING IN A UNIVERSAL JOINT, D. Thoma, D. E. Universal joints are used to connect shafts, the axes of which intersect at an angle of 90 deg. or less. If the shafts transmit no moment of torsion, the universal joint does not oppose the free variation of the angle of intersection of the two shafts and permits a free oscillation of one shaft axis relatively to the other about the center of the joint. This being so, it is easy to neglect mistakenly the fact that this resistance-free ability of oscillation persists only until the moment when the shafts begin to transmit a torsional moment, and that if the angle of intersection of the two shafts is other than zero, the universal joint as a rule must transmit the bending moment in addition to the torsion moment.

Even a superficial consideration will show that the universal joint actually exerts a bending moment on the shafts. Whatever may be the axis of the moment transmitted between the shafts through the means of the joint, it forms with the axial direction of at least one of the two shafts an angle equal to or more than half the angle between the shafts, so that the moment, at least with respect to one of the shafts, has a component normal to the axis of that shaft, which means a bending moment.

Since the conditions with respect to the two shafts are substantially symmetrical as a rule, both shafts will have to undergo the effect of a bending moment.

The universal joint coupling is a machine element having an extensive application, and it may be worth while, therefore, to investigate more closely the forces acting thereon. This is practically of interest in connection with certain tests on the critical speed of rapidly rotating shafts where the universal joint plays an important part.

The investigation of the forces presupposes the movements of the joint itself and of the shafts. Let us assume, as in Fig. 9, a system of rectangular coördinates such that both shafts lie in the x-y plane and that the positive z axis is located normally to the plane of the drawing and is directed upward. The angles of rotation of the shafts are measured from the position shown in Fig. 9, which may be called position A. Fig. 10 shows the general location of the coupling: The shaft I is rotated from the position A through an angle φ and the shaft II through an angle ψ in the direction of the arrow. We shall consider φ as an independent variable and shall determine ψ as a function of φ.

Let P be some point on the axis of the part of the universal joint belonging to the shaft I, and l its distance from O which is the point of intersection of the axes of the shafts and of the arms of the universal joints. The projection of OP shown in Fig. 10 is then equal to $l \cos \varphi$ and hence the coördinates of P are

$$x = l \cos \varphi \cos \alpha$$
$$y = -l \cos \varphi \sin \alpha$$
$$z = l \sin \varphi$$

From this it is found that the cosines of the angles α_1, β_1 and γ_1 which are enclosed between the axis of the arm of the universal joint belonging to shaft I and the axes of the coördinates are

$$\left.\begin{aligned} \cos \alpha_1 &= \cos \varphi \cos \alpha \\ \cos \beta_1 &= -\cos \varphi \sin \alpha \\ \cos \gamma_1 &= \sin \varphi \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots [1]$$

In a similar manner are found the cosines of the angles α_2, β_2 and γ_2 which are enclosed between the axis of the arm of the universal joint belonging to shaft II and the axis of coördinates, these cosines being

$$\left.\begin{aligned} \cos \alpha_2 &= -\sin \psi \\ \cos \beta_2 &= 0 \\ \cos \gamma_2 &= \cos \psi \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots [2]$$

The directions of the two arms of the universal joint are not, however, independent of each other, the arms being connected with each other in such a manner that they are always at right angles to each other. The usual formula of analytical geometry of space gives therefore the relation—

$$\cos \alpha_1 \cos \alpha_2 + \cos \beta_1 \cos \beta_2 + \cos \gamma_1 \cos \gamma_2 = 0$$

If we insert into this formula the values from Equations [1] and [2], we obtain after transforming—

$$\sin^2 \psi = \frac{\sin^2 \varphi}{\cos^2 \alpha + (1 - \cos^2 \alpha) \sin^2 \varphi} \quad \ldots\ldots\ldots [3]$$

This situation may also be expressed in the form

$$\tan \psi = \frac{1}{\cos \alpha} \tan \varphi \quad \ldots\ldots\ldots\ldots\ldots\ldots [4]$$

which will be used later on in this article and which is very simple.

The Action of the Forces. For the sake of simplicity it may be assumed that the joint transmits only moments but not individual forces. This assumption is usually satisfied at least if the joints are properly manufactured and installed, or if the journals of the arms have sufficient axial play in the bearings to take up the inequalities of manufacture, and furthermore we may assume that at least one of the two shafts is displaceable in an axial direction and will not take up any forces directed along its axis. The universal joint itself is considered as lacking either in mass or weight.

It is further assumed that shaft I is the driver. The joint transmits then the moment taken from shaft I unchanged in either magnitude or direction to shaft II. The arms of the joint are rotatable in the forks on the shafts and furthermore are

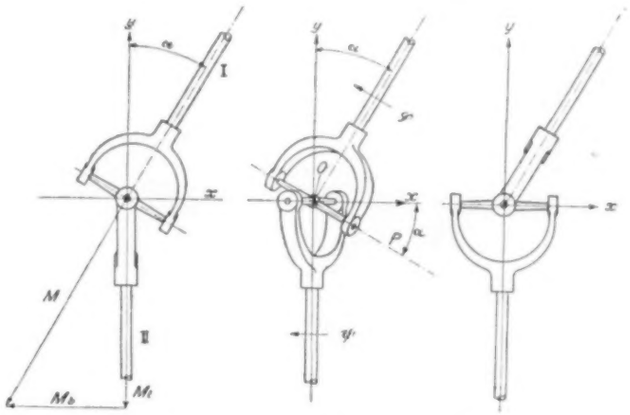


FIG. 9 UNIVERSAL JOINT IN POSITION A
FIG. 10 UNIVERSAL JOINT IN INTERMEDIATE POSITION
FIG. 11 UNIVERSAL JOINT IN POSITION B

assumed to be rotatable without friction; the axis of the moment which the joint takes up from shaft I and the fork located thereon is, therefore, normal to the arm held in that fork; the axis of the moment equal thereto in magnitude and direction which the part of the joint transmits to the fork on shaft II, and thereby to shaft II itself, is normal to but inverse in direction with respect to the arm of the joint located in that fork. The axis of the moment transmitted by the joint is thereby determined as the normal to the two arms of the joint, or, as one may express it otherwise, is the normal to a plane passing through the two arms.

In the position B (Fig. 11) this normal coincides with the axis of shaft II and the universal-joint coupling transmits to shaft II a pure torsion moment. In the position A (Fig. 9) the normal deviates most from the axis of shaft II, viz., by the angle α. Hence there the joint transmits to shaft II a bending moment $M_b = M_t \tan \alpha$ in addition to the torsion moment M_t. The forces acting on shaft I in both positions are just the reverse of this.

In order to estimate numerically the moments occurring in the intermediate positions, we shall designate the angles between the normals to the arms of the joint with the axes of coördinates by letters λ, μ and ν. We shall further designate the total moment transmitted to shaft II by M, the component of M in the x direction by M_x (= bending moment about x-axis) and the component (occurring in intermediate positions) in the z direc-

tion by M_z (= bending moment about the z-axis). It is then obvious that

$$M_t = M \cos \mu, M_x = M \cos \lambda, M_z = M \cos \nu$$

In addition to the torsion moment M_t, the transmission of which is the purpose of employing the joint, there are transmitted to shaft II also the bending moments—

$$\left.\begin{aligned} M_x &= \frac{\cos \lambda}{\cos \mu} M_t \\ \text{and} \\ M_z &= \frac{\cos \nu}{\cos \mu} M_t \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots [5]$$

It is necessary then to determine the values of cos λ, cos μ and cos ν. But according to the definition given above λ, μ and ν are the angles which the normals to the arms of the joint (α_1, β_1 and γ_1 and α_2, β_2 and γ_2) make with the axes of the coördinates; these angles are then determined by known equations of analytical geometry, viz.:

$$\cos \lambda = \cos \beta_1 \cos \gamma_2 - \cos \beta_2 \cos \gamma_1$$

and similar equations for the other two angles. In these equations account has been taken of the fact that the directions given by α_1 β_1 γ_1 and α_2 β_2 γ_2 are themselves at right angles to each other. If we insert into these equations the values from Equations [1] and [2] we obtain

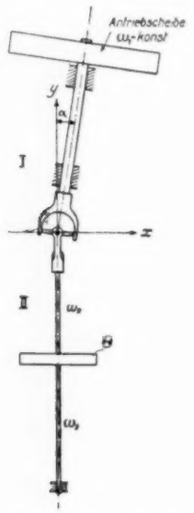


FIG. 12 UNIVERSAL JOINT DRIVE SUCH AS HAS BEEN INVESTIGATED BY O. FOEPPL
(*Antriebschiebe* ω_1 = *Konst.*, Driving Pulley ω_1 = Constant.)

$$\begin{aligned} \cos \lambda &= -\cos \varphi \cos \psi \sin \alpha \\ \cos \mu &= -\sin \varphi \sin \psi - \cos \varphi \cos \psi \cos \alpha \\ \cos \nu &= -\cos \varphi \sin \psi \sin \alpha \end{aligned}$$

where Equation [4] holds good for the relation between φ and ψ. By inserting these values into Equation [5] we obtain the comparatively simple formulae—

$$M_x = \frac{\sin \alpha \cos \alpha}{\cos^2 \alpha + \tan^2 \varphi} M_t \ldots\ldots\ldots\ldots [6]$$

$$M_z = \frac{\sin \alpha \tan \varphi}{\cos^2 \alpha + \tan^2 \varphi} M_t \ldots\ldots\ldots\ldots [7]$$

As an example of the application of the above, may be investigated the system shown in Fig. 12, which is of particular interest because of the observations therein published by O. Foeppl in the *Zeitschrift des Vereines deutscher Ingenieure*, 1919, p. 867.

The moment of inertia of the driving-belt pulley is so large as compared with the moment of inertia θ of the small flywheel pulley that the angular velocity of shaft I, which is ω_1, may be considered as being constant. The angular velocity of shaft II is $\omega_2 = \omega_1 \frac{d\psi}{d\varphi}$ and its angular acceleration is

$$\frac{d\omega_2}{dt} = \omega_1 \frac{d}{dt}\left(\frac{d\psi}{d\varphi}\right) = \omega_1 \frac{d}{d\varphi}\left(\frac{d\psi}{d\varphi}\right)\frac{d\varphi}{dt}$$

and since $\frac{d\varphi}{dt} = \omega_1$

$$\frac{d\omega_2}{dt} = \omega_1^2 \frac{\alpha^2 \psi}{d\varphi^2}$$

The moment of torsion transmitted to shaft II by the joint in order to cause it to move is therefore

$$M_t = \theta \frac{d\omega_2}{dt} = \theta \omega_1^2 \frac{d^2\psi}{d\varphi^2} \ldots\ldots\ldots\ldots [8]$$

The bending moments M_x and M_o can then be derived from Equations [6] and [7]. In order to carry out the computation we must first determine $\frac{d^2\psi}{d\varphi^2}$ by double differentiation of Equations [3] and [4]. By substituting this value in Equation [8] and by substituting the value of M_t thus obtained in Equations [6] and [7], we obtain for M_t, M_x and M_z rather complicated expressions which may, however, be materially simplified when the angle α is not very large, as then one may neglect the expression $(1 - \cos \alpha)^2$. This is permissible even for fairly large angles as, for example, $(1 - \cos 8.5 \text{ deg.})^2 = 0.00012$. If this is done we obtain

$$\begin{aligned} M_t &= -2\theta \omega_1^2 (1 - \cos \alpha) \sin 2\varphi \\ M_x &= -\theta \omega_1^2 \sin \alpha (1 - \cos \alpha) (\sin 2\varphi + \tfrac{1}{2} \sin 4\varphi) \\ M_z &= -\tfrac{1}{2} \theta \omega_1^2 \sin \alpha (1 - \cos \alpha) (1 - \cos 4\varphi) \end{aligned}$$

From the last two equations it appears that the shaft II receives through the universal joint powerful impulses tending to produce bending with a frequency double and quadruple the number of revolutions, and these impulses create new critical speeds and may entirely overshadow other effects. (*Schweizerische Bauzeitung*, vol. 75, no. 17, Apr. 24, 1920, pp. 187-188, 4 figs., *t.A*)

Gyroscopic Phenomena in Synchronous-Motor Drive of Reciprocating Compressors

FLYWHEEL EFFECT FOR SYNCHRONOUS MOTORS CONNECTED TO RECIPROCATING COMPRESSORS, R. E. Doherty. From an analysis of mechanical and electrical conditions of operation of synchronous motors connected to reciprocating apparatus it appears that there is a very close relation between the flywheel effect and the proper design of the motor.

Two motors of similar design are, for example, installed on different types of compressors; one operates well and the other does not. It appears, for example, that the motor gives trouble from surging and hunting. Then the flywheel is removed and the operation becomes satisfactory. In another instance, however, in which surging or hunting occurs, the flywheel is added and the trouble is cured. It would appear, therefore, that there can be either too much or too little flywheel and the author offers a method of solving this problem.

To do this, an analogy is offered first, such as Fig. 13, where two trains are assumed to be running side by side at constant speed and abreast of each other.

Under these conditions the driving force of the trains is exactly equal to the opposing forces of friction, windage, etc., and the position may be called "stable position."

Assume, however, that at an instant designated by O the driving force on train A is suddenly increased by an amount indicated in the figure and that after a time period t, this excess is suddenly removed. The presence of this added force will affect the velocity and relative displacement of trains A and B in the following manner. The excess force a being consumed entirely in the acceleration of the train may be used to represent graphically the product of acceleration $\times$ time, that is, excess velocity. But the result of its application will be that while train B reaches point m, Train A will have gone further, viz.,

to point *n*. The excess displacement *mn* is represented by the maximum ordinate at the end of curve *c*, and the idea is that it is possible from the curve of unbalanced force impressed upon a mass to find the change in both velocity and displacement simply by integrating the area of the loops in the unbalanced force diagram. The first integration gives velocity and the second gives displacement.

From this the author proceeds to the consideration of a case where, instead of the momentary excess force described above, a periodically varying force is applied. The resultant curve of velocity will then be as shown at *e* and the displacement curve at *f* shows the position of train *A* first ahead and then behind the "stable" position.

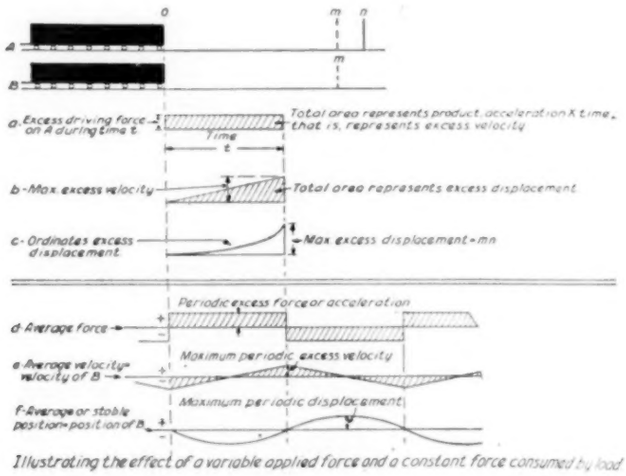


FIG. 13 DIAGRAMS SHOWING HOW PERIODIC RELATIVE DISPLACEMENT OF TWO TRAINS IS DERIVED FROM CURVE OF UNBALANCED DRIVING FORCE

One part of the problem of determining the proper flywheel effect for synchronous motors direct-connected to reciprocating compressors is illustrated in this way,—that it is required to find what mass train *A* must have in order to limit to a definite amount the plus and minus displacement, as shown in *f*, when a given periodic variation in the driving force is impressed upon train *A*.

A synchronous machine driving an air compressor will have a pulsating speed on account of the pulsating torque of the compressor, and the variable torque on the motor will cause it to displace first ahead and then behind "reference positions" which might be marked on a similar motor running at constant speed. For electrical reasons, however, it is necessary to place limits to this displacement or deviation, and the real problem is to determine how much flywheel is required to keep the angular displacement within given required limits which can be worked out from the turning-effort diagram of the compressor.

The writer explains in considerable detail the processes of obtaining the turning effort curve for a reciprocating compressor which is done by integrating the areas under the plus and minus loops of a tangential force curve along lines indicated in connection with Fig. 13. This integration gives the ordinates of the displacement curve which makes it possible with the given flywheel effect in the motor and a given tangential curve, to determine accurately what angular displacement would occur under the assumed conditions; or, conversely, what flywheel effect would be required to limit the angular displacement to a definite value.

Integration of the loops of the crank-effort and velocity curves by planimeter is, however, a very laborious process, and the writer recommends an analytical method which consists in expanding the unbalanced component in the crank-effort diagram, which to proper scale is the acceleration diagram, into a Fourier's series of sines and cosines, and integrating this equation twice for displacement. By proper substitutions the maximum angular displacement may be expressed in electrical degrees.

The author analyzes in considerable degree the electrical phenomena in a synchronous motor as affected by, and affecting, the flywheel effect. This part is not suitable for abstracting. (*A. S. R. E. Journal*, Nov. 1919, vol. 6, no. 3, pp. 159-177, 9 figs., *t*)

METALLURGY (See Heat Treatment; Furnaces)

MILITARY ENGINEERING

Schneider 155-mm. Gun

SCHNEIDER 155-MM. GUN. Description of the Schneider gun of the heavy field-artillery type allowing of firing at a flat trajectory and high-angle fire up to a positive angle of 40 deg.

The original article describes both the 1917 and 1918 patterns. The maximum range exceeds 10 miles with the projectiles weighing close to 95 lb. and having a muzzle velocity of close to 2200 ft. The gun fires from the carriage without any preparation or platform. Three rounds can easily be fired per minute and this rate can be increased to five rounds. The gun is shown in firing position in Fig. 14. It is of steel and consists of a tube, a jacket and a rear block forming an equalizing weight. The breech is closed by an interrupted breech mechanism with plastic obturator operated by hand. Firing is by percussion such that the device does not act until the breech is completely closed.

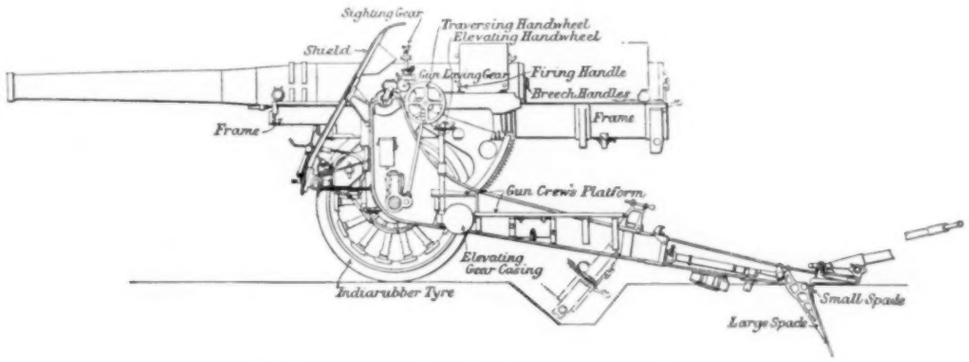


FIG. 14 SCHNEIDER 155-MM. GUN IN FIRING POSITION

A table is given showing particulars of this gun. (*Engineering*, vol. 109, no. 2833, April 16, 1920, pp. 512-513, 7 figs., *d*)

MOTOR-CAR ENGINEERING (See Internal-Combustion Engineering)

MUNITIONS (See Military Engineering)

RESEARCH (See Internal-Combustion Engineering)

SPECIAL MACHINERY

Machine for Boring Horizontal Holes in Clay

THRUST BORING IN EARTH. Description of a machine invented by Capt. A. R. Mangnall and made by a British company. It is claimed that this machine will pierce a hole 4 in. in diameter and 150 ft. long horizontally through heavy clay in half an hour. It is intended for cable laying, pipe laying, drainage or similar work. The machine is in a sense an outcome of the war. Several attempts were made to devise an apparatus which could be started from British trenches and bore under those of the enemy holes for mining and countermining. The action of the machine can best be compared with that of thrusting a stick into clay. The machine consists of a hydraulic cylinder of steel tube, carried on trunnions in a light steel frame. Inside the cylinder is a short piston with hinged guiding fingers.

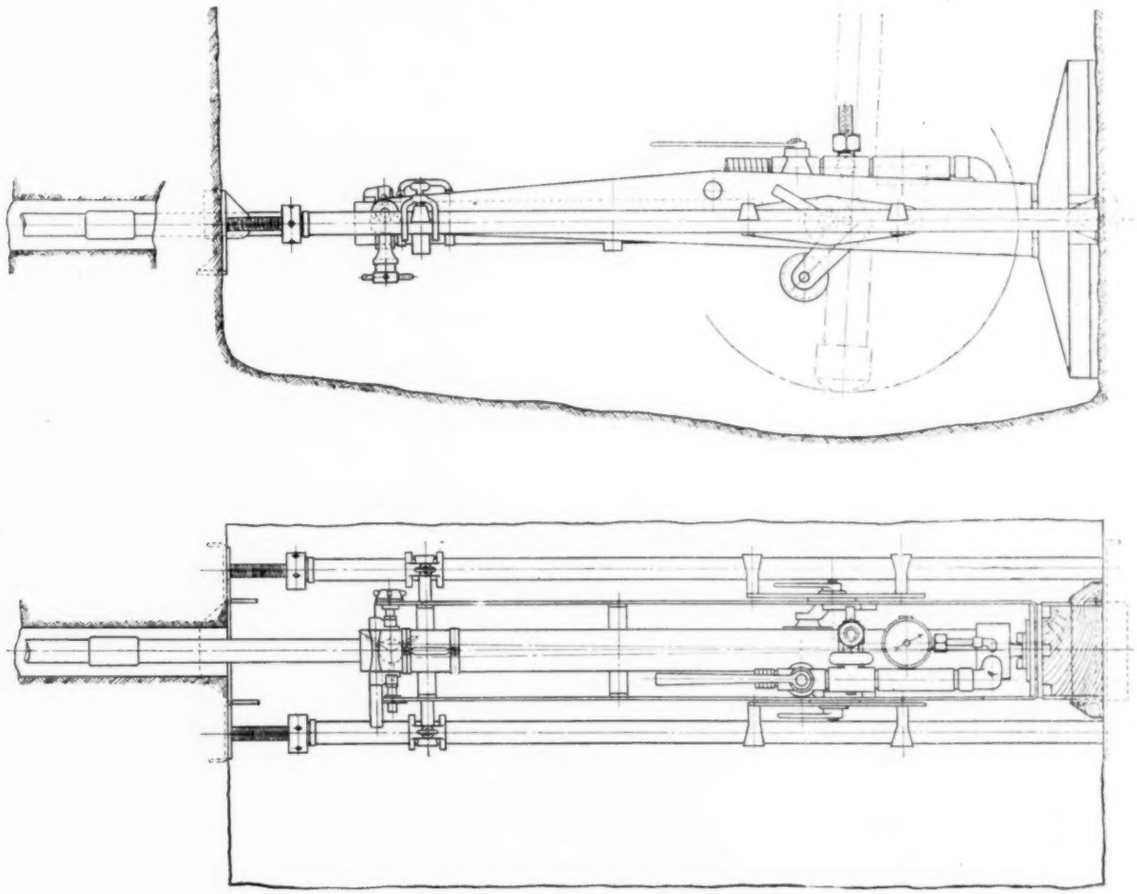


FIG. 15 MANGNALL EARTH THRUST BORER—GENERAL ARRANGEMENT

This "gun" complete on its framework is dropped into a pit dug in the ground to the depth required, a plate at the back of the framework or carriage pressing against a few timbers to distribute the load. The cylinder is connected by flexible pressure pipes to a little three-throw pump driven by a petrol engine. The exhaust water returns to the pump from which the pump draws. The operation of thrust-boring is begun by turning the gun up to a vertical position and dropping the "pilot" into it. The gun is then turned down and clamped in position, and hydraulic pressure is admitted behind the piston, pressing the pilot horizontally 4 ft. into the soil. The stroke being completed, the admission valve is closed and the exhaust valve opened—by one and the same lever—the gun is raised to the vertical and the first extension piece pressed into it. The exhaust water is then returned to the sump. The three guide fingers referred to keep the base of the extension piece in a central position. The gun is again placed horizontally, and the extension piece is attached to the end of the pilot by a simple pin joint. The pressure is put on again, and the pilot driven forward another 4 ft. Then the same operation is repeated, extension piece after extension piece being added until the pilot breaks through into a pit at the far end—150 ft. away. The pilot is then uncoupled and lifted out of the pit, and the extension pieces are withdrawn and uncoupled one by one. The whole operation of raising the gun, inserting an extension piece, lowering the gun, fixing the pin joint, and thrusting the piece home occupies something less than one minute.

The joint is extremely simple and ingenious. The extension pieces are tubes about 2½ in. diameter for a 4-in. hole, with muff couplings at the leading end. Through each coupling is drilled a pair of opposite holes; through the other end of each piece is drilled a corresponding pair of holes, but of smaller diameter. The pins are turned to fit the smaller holes freely, but at each end are reduced in diameter so as to leave a shoulder. The operator brings the holes opposite each other, slips the pin in position, and dabs a little bit of clay round the end. It is found that the clay locks the pins effectively and that they never fall out. The withdrawal of the extension pieces is easy, since their diameter is a good deal less than that of the hole. The method generally employed is to attach a rope to the last piece and carry it round a pulley. Two or three men on the surface can then pull the whole chain of extension pieces back until the next joint is reached. The operation is repeated until the operator in the pit can pull the rods back without assistance. An alternative method is to turn the gun up to a vertical position, and by means of suitably arranged ropes and pulleys employ it like the cylinder of an hydraulic crane. (*The Engineer*, vol. 129, no. 3354, April 9, 1920, pp. 369-371 and 376, 7 figs., *dA*)

STEEL MILLS (See Bureau of Standards)

TESTING (See Internal-Combustion Engineering)

TRANSPORTATION

THE STABILITY OF MOTOR OMNIBUSES. In view of the growth of the use of motor omnibuses for city transportation, an editorial in *The Engineer* in reference to the safety of this type of vehicle becomes of considerable interest. It would appear that within the past year there have been a number of cases in England where motor omnibuses overturned and there is a growing suspicion that the motor omnibus is not quite as safe a vehicle of travel as has been assumed hitherto.

Among the causes of this alleged condition are mentioned the carelessness of drivers who learned to take undue risks in France, the bad condition of the roads and the degree of overcrowding now permitted in England in the interior of the omnibuses.

These causes do not appear, however, to be capable of explaining some of the accidents and it would seem as if the real cause lay in the design of the omnibuses. As regards this latter, the motor omnibus used on the London streets is a vehicle weighing in service condition some 9850 lb., of which weight a little over 64 per cent is in the chassis. It is capable of carrying without overcrowding 36 people, representing on an average a load of 5400 lb. so that when fully loaded the vehicle and load weigh something in the neighborhood of 6½ tons.

Its center of gravity in service condition, but without load, lies low down, being only about 44.5 in. above the road surface and just a little above the level of the tops of the rear wheels. The gage of the wheels being 70 in., it follows that the vehicle will recover itself if it is tipped up until the rear axle is lying at 38 deg. to the horizontal. When the omnibus is fully loaded the center of gravity rises to 62 in. above the road surface so that in this condition the maximum heel from which the vehicle will recover itself is 29.5 deg. These figures do not take account of the fact that the body is mounted flexibly on the chassis. In an actual test the yielding of the springs permitted the vehicle to be tipped when empty until the center line of the body was inclined at 46 deg. to the vertical.

It would appear, therefore, that the motor omnibus is quite stable when stationary. When it is in motion the angles of heel mentioned above are a measure of its stability so long as its course is a straight line. The critical test for the stability of the vehicle arises when centrifugal force comes into play during the rounding of a corner. Taking 30 ft. as the radius of the curve and 7 miles per hour as the speed when rounding the corner, it would appear that the stability of the omnibus is reduced by a little over 18 per cent, and if the vehicle carries passengers on the top only the loss of stability is a trifle over 19 per cent. Under these circumstances the critical condition of equality between the upsetting moment and the righting moment will be reached if the heel amounts to 23¼ deg. with the vehicle fully loaded or 22½ deg. if the passengers are entirely on the top. These angles would be reached only if the wheels on the inner side of the curve were lifted off the ground to a height of about 27 in., a condition hardly likely to be encountered, and even this aggregation of unfavorable conditions is counteracted to a certain degree by the fact that the body of the vehicle is mounted on springs.

The stability of the modern motor omnibus may therefore be considered as satisfactory and while the vehicle could be made more stable this is hardly necessary and perhaps not even desirable, as increased stability could be obtained only at the cost of reducing maneuverability and this might lead to an increase of accidents on crowded streets.

It would appear, therefore, that such accidents of overcrowding as have occurred have been due to exceptional conditions present in each individual case.

It might be added in this connection that such accidents as overturning of an omnibus are practically unknown in New York City. (*The Engineer*, vol. 129, no. 3355, April 16, 1920, pp. 401-402, editorial, *g*)

CITRÖEN GEAR FOR ELECTRIC LOCOMOTIVES. Description of the application of Citröen gears for electric locomotives by the Oerlikon Works Company.

This is a result of tests over a period of many years. The locomotive put on the line in 1911 is still in service. It was, however, a comparatively slow-speed type. In 1913 another type was placed in service to run with commercial speeds as high as 70 km. (43.5 m.p.h.) and operate on rather heavy grades at speeds of about 30 m.p.h.

A somewhat strange phenomenon was noticed on that locomotive. Rather heavy vibrations occurred when the speed was between 24.5 and 24.8 m.p.h. and reached their maximum at speeds between 24.8 and 25.4 miles, but disappeared when the speed was between 25.4 and 25.7 m.p.h. The same phenomenon occurred during the slowing down and was maintained so long as the speed remained between 24.5 and 25.7 miles.

At first the trouble was thought to be due to an inaccurate division of the teeth, but had that been the case the oscillation would have increased between the speed of 25.4 and 43.5 miles in proportion to the square of the speed. These vibrations were so serious that they led in some instances to fracture of the coupling rods. It was clear that the vibrations arose through resonance. One of the causes of the resonance could be looked for in the play of the crankpin and coupling-rod bearings. Such a play, when it exists, has in itself an influence which is constant and is independent of the speed; this influence becomes serious only when it is amplified by resonance—that is, when another periodical cause is superimposed upon it. Here, apparently, this second cause has a fixed period which corresponds precisely to the speed of 24.8 to 25.4 miles, but just what its nature is does not appear to be clear yet, notwithstanding much experimental work.

The load is distributed on the axles by means of equalizers, as in the case of steam locomotives. The locomotive complete weighs in running order 108.6 metrical tons; the five central pairs of wheels and axles weighing each 2040 kg., and the two end ones 1530 kg. each, while the suspended load is 95,340 kg. On the other hand, the maximum designed load on a driving axle is 17,000 kg.; on this basis, and reckoning further on, a maximum load of 11,800 kg. for each end axle, the suspended load does not exceed 14,960 kg. for each of the five driving axles and 10,272 kg. for each of the two end axles. But the weight of a complete motor is made up as follows: Rotor, 4,715 kg.; pinion, 449 kg.; shaft, 459 kg.; stator, 6715 kg.; intermediate shaft and toothed wheel, 2410 kg.; crankplates, 400 kg.; making up a total of 15,150 kg. in round numbers. Since half the weight of each of the two motors is taken by the middle axle, as also a part of the weight of the frame plates and body, it is clear that the load over this middle axle must be in excess of that authorized by the regulations, so long as the rigidity of the frame is insufficient to transfer part of this load to the other axles, since the central load is distributed solely by special springs on the corresponding axle, without an equalizer. Consequently, if the conditions under which the frame plates undergo flection be gone into by using the Clapeyron formula, it is necessary to take into account the flection of the frame plate between the axles preceding and following the middle one, otherwise the middle axle would be loaded above the regulation figure.

The frame plate can thus only be considered as a girder resting on six bearings instead of seven, bearings which are on a level, while the central axle bearing exerts an upward force of 14,960 kg. (*Engineering*, vol. 109, no. 2839, May 26, 1920, pp. 712-714, 7 figs., *dt*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

ENGINEERING RESEARCH

A Department Conducted by the Research Committee of the A. S. M. E.

Endowment for Engineering Foundation

ENGINEERING FOUNDATION was organized to care for the generous gifts of Mr. Ambrose Swasey, the income from these gifts being devoted to engineering research. Since its organization the funds have been used to aid the National Research Council and others in performing research directly connected to engineering.

Potential benefits for the whole nation are very great, but these benefits cannot be gained without expenditure of effort and materials. Research workers must be supported. Equipment, materials, working places and traveling facilities must be provided. Since the benefits accrue to the profession, the industries and the public in general, support in large measure should come from general funds, such as those provided by endowments.

Although engineers, like other professional men as a class, are not wealthy, some individual engineers have large means. Engineering Foundation seeks to build up its endowment to dimensions worthy of the profession. Engineers connected with industrial and financial organizations having great resources can aid by convincing proper officials of corporations that the continued prosperity of our industries depends upon continued progress of research. Since the commercial and industrial establishments of the country reap the larger proportions of the financial profits arising from scientific and technological work, these establishments should contribute liberally to the support of research.

There are many problems relating to the materials and forces of engineering on which further knowledge is needed. Progress will be made approximately in proportion to the funds made available. But there are other kinds of problems which concern the engineer. No longer may one declare, as did Prof. J. H. Johnson a generation ago, that "Engineering differs from all other learned professions in this, that its learning has to do only with the inanimate world, the world of dead matter and force." Many acute social and economic questions of our day need the dispassionate, impartial, patient study of scientists and technologists. To these questions must now be applied the scientific method of collecting facts by thorough study, and the engineer's capacity for planning and performing, instead of ill-considered "reforms."

Occasionally experimental work is undertaken in accordance with a well-conceived plan as a necessary or desirable adjunct to the main operation. In such cases the exigencies of the main operation sooner or later interrupt the experimental work; or the men who have it in hand leave the force; or the information is gained but never written up; or the statement is buried in some report of limited circulation; or greater familiarity with research methods and a broader conception of the problem could, with small additional expense, have secured much more valuable results and have made them more generally useful.

The services described in the foregoing paragraphs, and many others, could be performed by Engineering Foundation, if adequate funds could be placed at its disposal. The Foundation does not plan to build laboratories and conduct research work directly, but rather to stimulate, coördinate and support research work in existing scientific and industrial laboratories, coöperating, in so far as possible, with the National Research Council.

Mr. Charles F. Rand, of 71 Broadway, New York, Past-President of United Engineering Society, and of the American Institute of Mining and Metallurgical Engineers, was elected Chairman of Engineering Foundation March 19, to succeed Dr. W. F. M. Goss, resigned. With the collaboration of Mr. Swasey, Mr. Rand is actively seeking additions to the endowment which will swell the total to at least a million dollars in the near future. Mr. Swasey's gifts amount to $300,000.

The office of Engineering Foundation is in the Engineering Societies Building, 29 West 39th St., New York. Further information may be had by addressing this office or the chairman. A booklet giving an account of the Engineering Foundation and its work will be mailed upon request.

A—Research Results

The purpose of this section of Engineering Research is to give the origin of research information which has been completed, to give a résumé of research results with formulæ or curves where such may be readily given, and to report results of non-extensive researches which in the opinion of the investigators do not warrant a paper.

Cement and Other Building Materials A4-20 The Use of Wet and Dry Sand for Concrete. Concretes made from Potomac sand and gravel in various proportions from 1:1½:3 to 1:3:6 with various extremes of flowability have shown that when the aggregates are proportioned by volume measure it is found that wet aggregate requires from ½ to 1 bag of cement per cu. yd. more than concrete with dry aggregate. Sand is generally wet or at least moist when used so that the full difference may never be apparent in field practice, yet the use of sand from a pile which has just been wet from the rain will result in the employment of more cement for a given volume of concrete than would have been the case had the work been done on a dry day. Marked improvement in the working qualities of concrete will be noted under the usual conditions when the relative volume of sand is increased and the gravel proportionately reduced. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Heat A2-20 The Efficiency of Insulation Used in Cold-Storage Work. The Bureau of Standards has conducted a number of experiments on the coefficient of conduction through insulating materials. This has been done by the flat-plate method, in which the coefficient of conduction rather than the coefficient of transmission has been determined. Preliminary results have been transmitted to the June Meeting of the American Society of Refrigerating Engineers and issued by them in their Journal and also issued by the Bureau of Standards as a scientific paper. Address S. W. Stratton, Director, Bureau of Standards, Washington, D. C.

Leather and Glue A1-20 Service Tests on Chrome-Tanned and Oak-Tanned Sole Leather. Twenty-five service tests have shown that chrome leather outwore oak leather by about 23 per cent per unit thickness. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Metallurgy and Metallography A11-20 Heat Treatment of High-Chromium Steel. Experimental work on samples of high-chromium steel containing C 0.29 per cent, Mn 0.38 per cent, Si 0.70 per cent, and Cr 13.2 per cent has been completed and a report submitted to the Journal of the American Society of Automotive Engineers. The samples were heated to various temperatures and quenched in oil. The following results are shown:

a Hardness by Brinell and Shore instruments increases with the temperature until 1950 deg. fahr. is reached. Maximum range of hardness is generally obtained by quenching from this temperature up to the highest heat used, but in some cases this hardness actually decreases due to the retention of the solid solution.

b Quenching from about 1750 deg. fahr. develops the best combination of strength and ductility which is not coincident with maximum hardness. Quenching from this or a lower temperature does not retain all the carbide in the solution, as is the case in samples quenched from considerably higher temperatures, notably 2100 deg. fahr. and 2250 deg. fahr.

c Ductility as measured by elongation and reduction is very low when quenching occurs from 1850 deg. fahr. or above.

d Short-time tempering at temperatures above 800 deg. fahr. decreases brittleness. Ductility is increased to a greater extent in sample quenched from 1750 deg. than those at higher temperatures. Tempering above 800 deg. fahr. decreases the strength and hardness in a marked manner, although ductility is increased. Address S. W. Stratton, Bureau of Standards, Washington, D. C.

Properties of Engineering Materials A8-20 Strength of Steel. The relation between the elastic strengths of steel in tension, compression and shear is the subject of Bulletin No. 115, Engineering Experiment Station of the University of Illinois, by Prof. F. B. Seely and W. J. Putnam. The Bulletin presents the results of experiments on soft, mild and medium carbon steels and vanadium, nickel and chrome-nickel steels. The elastic strengths in tension, compression and shear are given for each of the six grades. The shearing strength in torsion was found from solid cylindrical specimens and thin-walled hollow specimens. The main object of the investigation was to determine carefully the elastic shearing strength of ductile and semi-ductile and find the ratio of the elastic shearing strength to the elastic tensile strength.

Ductile rods or specimens from rolled shapes when tested in tension showed a sudden or abrupt elastic breakdown. The elastic shearing failure of solid cylinders is also abrupt with well-defined yield point. This seems to indicate that tensile failure is really a shear failure. The hollow thin-walled specimens do not show such an abrupt elastic failure in shear, and therefore the shearing breakdown is more gradual than the corresponding tensile breakdown. The following abridged conclusions are made at the end of the Bulletin:

1 The correct value of the elastic shearing strength and yield point in shear of steel as measured by the proportional limit or the useful limit point may be determined from a torsion test of a hollow thin-walled cylindrical specimen.

2 The correct value of the elastic shearing strength of steel as measured by the proportional limit or the useful limit point may be taken, with reasonable accuracy, as eighty-five hundredths (0.85) of the elastic strength obtained from a torsion test of a solid cylindrical specimen. The correct value of the yield point for the more ductile materials is slightly more than eighty-five hundredths (0.85) of the yield point obtained from a test of a solid torsion specimen.

3 A solid cylindrical torsion specimen may be used to obtain test results. The character or progress of the breakdown of the elastic action may be obscured in the test of the solid specimen. Test results obtained from a solid specimen may also be used to judge of the general properties, quality and reliability, of the materials.

4 The correct value of the elastic shearing strength of steel as measured by the proportional limit or the useful limit point is from fifty-five to sixty-five hundredths (0.55 to 0.65) of the elastic tensile strength and may be taken with reasonable accuracy as six-tenths (0.6) of the elastic tensile strength. The maximum shear theory of the failure of elastic action of ductile steel (sometimes called Guest's Law) is, therefore, not an accurate statement of the law of elastic breakdown, since Guest's Law assumes that the elastic shearing strength is one-half (0.5) of the elastic tensile strength. The maximum-shear theory as expressed by Guest's Law, however, is of much use in obtaining approximate results.

5 Contrary to the general belief, the breakdown of the shearing elastic action of ductile and semi-ductile steel as found in these tests is gradual; more gradual, as a rule, than the failure of elastic action in a tension specimen.

6 The amount of hot-rolling received by steel may have a marked effect upon the relation of the elastic tensile and compressive strengths. For the material from ¾-in. and ⅞-in. bars, the elastic compressive strength is somewhat greater (about 5 per cent) than the elastic tensile strength, whether the elastic strength is measured by the proportional limit, useful limit point or the yield point. For the material from the 3½-in. bars, the compressive proportional limit is very much greater (27 per cent) than the tensile proportional limit, while the compressive yield point is somewhat less (4 per cent) than the tensile yield point.

7 It appears, therefore, that the choice of the criterion of elastic strength may be of considerable importance in some cases, and that the usual tensile test of material may require supplementary compressive tests or a better correlation between test data and the amount of treatment received during rolling before the elastic properties of the material as obtained from tensile test data can be relied upon.

8 The elastic strength and ultimate strength of steel in tension, in compression, and in shear is affected little, if any, by the direction of rolling in the case of a slab 2 in. thick, although the ductility, as measured in tension tests by the percentage of elongation and percentage of reduction of area, is materially less when the stress is perpendicular to the direction of rolling than it is when the stress is parallel to the direction of rolling.

University of Illinois, Engineering Experiment Station, Urbana, Ill. Address C. R. Richards, Director.

Properties of Engineering Materials A9-20 Magnetic Uniformity of Steel. The Bureau of Standards has recently tested 54 bars 1 in. in diameter, 12 ft. long for magnetic uniformity. The bars were intended for experiments on heat treatment of carbon steel. The determination was made by passing the test specimen at a uniform rate through a magnetizing solenoid energized by direct current and noting the deflection on a sensitive instrument connected to a system of test coils located within the magnetizing solenoid. With uniform material no deflection occurs while variations in uniformity gave deflections of which a photographic record was made. Five bars were found to give relatively large deflections at certain points. Regions thus located were cut out and not used in the investigation. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Welding A1-20 Electric Arc Welding. In an investigation about to be published by the Bureau of Standards it has been discovered that fusion welds differ from all other types in that the metal of the weld is essentially a casting. No refinement of this metal is possible in the method as ordinarily carried out. The characteristic properties of the arc-fused metal have been determined in this study. The work shows that skill, care and patience on the part of the operator is a matter of vital importance. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

B—Research in Progress

The purpose of this section of Engineering Research is to bring together those who are working on the same problem for coöperation or conference, to prevent unnecessary duplication of work and to inform the profession of the investigators who are engaged upon research problems. The addresses of these investigators are given for the purpose of correspondence.

Automotive Vehicles and Equipment B2-20 Dynamics of Load Suspension on a Motor Vehicle. A study of the forces involved in the action of tires, axles, springs and body of truck when passing over obstructions in the path of the wheels. An analysis of curves obtained by driving a truck at constant speed across the field of a camera in the dark, lights on the body and axles tracing the motion of those parts on the camera plate. This includes the determination of the force of impact on the obstruction and the pavement beyond the obstruction. Address Asst. Prof. W. E. Lay, Charge of Automobile Engineering, University of Michigan, Ann Arbor, Mich.

Automotive Vehicles and Equipment B3-20 Fuel Economy of a Motor Vehicle. Much has been said about the apparent improvement in operation of the automobile engine on a summer evening. Preliminary tests have indicated the possibility of a daily cycle in the variation of fuel-mileage economy. The attempt is being made by means of a series of 24-hour runs to determine upon which variable or combination of variable conditions the change in fuel mileage depends. Address Asst. Prof. W. E. Lay, Charge of Automobile Engineering, University of Michigan, Ann Arbor, Mich.

Cement and Other Building Materials B2-20 Building Columns Under Fire. The Underwriters' Laboratory of Chicago is working on a report of a test of 105 columns under fire. These columns have been loaded to capacity and in this condition were subjected to the standard fire temperatures. The work is being done in coöperation with the Bureau of Standards, National Board of Fire Underwriters and the Associated Factory Mutual Fire Insurance Companies. It has been in progress for three years and the report will soon be made. Address Underwriters Laboratories, 207 E. Ohio St., Chicago, Ill.

Fuels, Gas, Tar and Coke B1-20 Carburetion of Fuels. See *Internal-Combustion Motors B7-20.*

Heating B2-20 Sample House in Saskatchewan. Seven different types of house built as 6-ft. cubes of different types of building construction have been erected at the college at Saskatoon, Sask. The temperature in this locality reaches 50 deg. below zero with no wind and 15 to 20 deg. below zero with a strong wind. Recording thermometers of the Leeds and Northrup type are being used. The amount of heat to warm these houses is being determined. Address Prof. A. R. Greig, Saskatoon, Sask.

Heating B3-20 Direct-Indirect Systems. The Mechanical Engineering Department of the Iowa State College has been making tests on direct-indirect systems of heating. Address Prof. M. P. Cleghorn, Iowa State College, Ames, Ia.

Heating B4-20 Loss of Heat from Underground Mains. The Mechanical Engineering Laboratory of the University of Michigan is coöperating with the Ric-wil Company of Cleveland, Ohio, and the Research Bureau of the American Society of Heating and Ventilating Engineers in attempting to secure data from experiments upon a bare pipe buried in the ground whereby the paths of heat flow can be traced. Address Prof. J. E. Emswiler, University of Michigan, Ann Arbor, Mich.

Heating B5-20 Velocities in Hot-Water Heating Systems. The Mechanical Engineering Department of the University of Michigan is conducting some experiments to determine the velocity of water when the radiator is located upon the first, second and third floor above the heater when natural circulation of the water is employed. Address Prof. J. E. Emswiler, University of Michigan, Ann Arbor, Mich.

Metallurgy and Metallography B7-20 Tensile Properties of Boiler Plates. Boiler plate rolled at a blue heat (300 deg. cent.) has been used to determine the properties at elevated temperatures and the effect of blue work. The effect of low-temperature annealing is to be determined. Special apparatus has been constructed to determine the effect of the rate of loading on the elastic limit at elevated temperatures, using a motion-picture camera. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

C—Research Problems

The purpose of this section of Engineering Research is to bring together persons who desire coöperation in research work or to bring together those who have problems and no equipment with those who are equipped to carry on research. It is hoped that those desiring coöperation or aid will state problems for publication in this section.

D—Research Equipment

The purpose of this section of Engineering Research is to give in concise form notes regarding the equipment of laboratories for mutual information and for the purpose of informing the profession of the equipment in various laboratories so that persons desiring special investigations may know where such work may be done.

Delaware College D1-20 The small laboratory at Delaware College is equipped with two single-expansion engines, a condenser, a small air compressor, a 30,000-lb. testing machine, a hydraulic ram, two gas engines, and a centrifugal pump. Address Merrill V. G. Smith, Delaware College, Newark, Del.

General Bakelite Company D1-20 The Physical Laboratory of the General Bakelite Company at Perth Amboy, N. J., contains the following apparatus for use in their research work:

One 100,000-volt, 60-cycle testing transformer with facilities for making tests on standard A. S. T. M. molded samples in air and oil at full voltage.

One 30,000-lb. Olsen Universal testing machine.

Insulating resistance outfit with direct current at 15,000 volts with galvanometer of sensitivity of 5×10^{-10} for resistance of five million megohms.

Olsen heat-distortion testing machine for molded insulation materials according to A. S. T. M. standards.

Special apparatus for determining plastic quality.

Auxiliary apparatus for standard laboratory work.

Address Gilbert L. Peak, Electrical Engineer, General Bakelite Company, Perth Amboy, N. J.

E—Personal Notes

The purpose of this section of Engineering Research is to give notes of a personal nature regarding the personnel of various laboratories, methods of procedure for commercial work or notes regarding the conduct of various laboratories.

F—Bibliographies

The purpose of this section of Engineering Research is to inform the profession of bibliographies which have been prepared. In general this work is done at the expense of the Society. Extensive bibliographies require the approval of the Research Committee. All bibliographies are loaned for a period of one month only. Additional copies are available, however, for periods of two weeks to members of the A.S.M.E. or to others recommended by members of the A.S.M.E. These bibliographies are on file in the offices of the Society.

Electrochemistry F2-20 Electric Furnaces. The electric furnace as applied to metallurgy. A reading list from 1900 to 1919 by Clarence J. West, a paper presented to the American Electrochemical Society at Boston, April 8 to 10, 1920. See Vol. 37 of the Transactions of the American Electrochemical Society. A bibliography of 92 pages of general articles on electrodes, iron, steel alloys, ferrosilicon, ferromanganese, ferrochromium, ferrotungsten, ferromolybdenum, non-ferrous metals, brass, copper, nickel, tin and miscellaneous metals. Address Arthur D. Little, Inc., Cambridge, Mass.

Fuels, Gas, Tar and Coke F4-20 Fuel-Oil Use in Locomotives. A bibliography of one page. Address A.S.M.E., 29 West 39th St., New York.

Cleveland Engineers Hold Joint Meeting

Cleveland Engineering Society Celebrates Its Fortieth Anniversary with Engineers' Club of Dayton, A.S.M.E. and Other Local Sections Coöperating

The fortieth annual meeting of the Cleveland Engineering Society was held on June 8 with an attendance of nearly four hundred. A delegation of seventy-eight members of the Engineers' Club of Dayton was present and contributed to the success of the meeting. The Cleveland A. S. M. E. Section had charge of the arrangements for the several trips of inspection which were made during the day, which included visits to a number of the leading industrial plants of the city.

During the morning while registration was progressing, motion pictures were shown at the rooms of the Cleveland Engineering Society on the fourteenth floor of the Hotel Statler. These illustrated operations in the plant of the Cleveland Automatic Machine Co., with talks by E. E. Blundell on the Cleveland Automatic Turret Machines and by H. T. Simmons, of the Wellman-Seaver-Morgan Co., on An Improved Car Dumper.

The Cleveland University Club was the scene of a banquet in the evening, at which inspiring addresses were given by Col. Edward A. Deeds, of Dayton, Ohio, and Dr. E. J. Cattell, of Philadelphia, Pa. Colonel Deeds spoke on The Benefits of Engineering Associations and he pointed out the many opportunities awaiting the engineering profession through coördinated action on the part of the local and national engineering societies. He stated that he was thoroughly convinced that an analysis of the reasons for the remarkable development of many of our large industrial cities, such as Cleveland, would undoubtedly show that the local engineering organizations had played a very important part in the growth of such places. He emphasized the fact that such a city as Dayton, with no seaport facilities, was largely dependent upon the industrial activity of the community for its progress, and through the establishment of a strong local engineering organization like the Engineers' Club of Dayton, provision was made for fostering the research and experimental work so essential for the continued growth and prosperity of the city. In closing he extended a hearty and most cordial invitation to the engineers of Cleveland to visit Dayton next year, because he believed that the exchange of ideas and the mingling of engineers of one locality with those of another advance the profession to a much greater extent than is appreciated.

Honorary membership in the Cleveland Engineering Society was conferred upon Dr. Dayton C. Miller, of the Case School of Applied Science, for his achievements in developing instruments for measuring the distance and direction of sound, and whose research work in sound waves and their photography has been notable. The other honorary members include such notable engineers and scientists as Charles H. Benjamin, Charles F. Brush, Gustav Lindenthal, Albert A. Michaelson, E. W. Morley, W. H. Searles, Ambrose Swasey, and Worcester R. Warner.

Mr. Edwin S. Carman, retiring president of the Cleveland Engineering Society, gave a brief outline of the work accomplished by the organization during his term of office and emphasized especially the degree to which it has succeeded in bringing about coöperation with the local sections of the various national engineering organizations and other local engineering groups. All such activities in Cleveland are now concentrated in the rooms of the Cleveland Engineering Society. The new president, Mr. William J. Carter, a consulting civil engineer, assured the organization of his best service and promised to do everything to develop the activities of the society along public service lines and in the leadership in such matters as suitable legislation in the state of Ohio as to the licensing of engineers. The Cleveland Engineering Society has long taken an active interest in municipal engineering matters, and the community has come to look to it for guidance in this direction. Col. Elliott H. Whitlock made an excellent toastmaster and the general atmosphere of the meeting was such as to justify the statement that it "was the best ever."—E. H.

WORK OF THE BOILER CODE COMMITTEE

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in MECHANICAL ENGINEERING, in order that any one interested may readily secure the latest information concerning the interpretation.

Below are given the interpretations of the Committee in Cases Nos. 253, 268, 275, 278, 283, 287, 288, 291-298 inclusive, as formulated at the meeting of April 22, 1920, and approved by the Council. In accordance with the Committee's practice, the names of inquirers have been omitted.

CASE NO. 253 (Previously annulled)

Inquiry: Is it permissible under the requirements of the Boiler Code to use for boiler construction, tubes or flues that have been formed into the desired lengths by welding together at their ends, short lengths of such tubing by the electric pressure welding process, provided the metal upset at the weld is immediately rolled down to the proper thickness while under the heat of the weld?

Reply: It is the opinion of the Committee that while there is no objection to the safe-ending of tubes for fire-tube boilers by a suitable forge or pressure welding process, the suggested method of making the tube from a number of short pieces would be an objectionable practice. The Committee does not consider the practice of safe-ending of tubes to be a suitable one for water tube boilers.

CASE NO. 268 (Reopened)

Inquiry: a Inasmuch as the discharge of feedwater into vertical fire-tube boilers in accordance with the requirement of Par. 316 of the Boiler Code has caused serious difficulties from leaky tubes in the lower tube sheet, a reconsideration is requested of Case No. 145, in which the opinion of the Boiler Code Committee is given that the discharge of feedwater in the water leg of a vertical fire-tube boiler is not permissible.

b In case it is ruled that such discharge of feedwater into the water leg of a vertical fire-tube boiler is not allowed, is it permissible to protect the feedwater discharge through a feedwater pocket riveted within the shell at a point above the water leg, with handhole opening for cleaning?

Reply: a It is the opinion of the Committee that Par. 316 does not permit of discharging the feedwater in the water leg of a vertical fire-tube boiler, and that difficulties with leaky tubes may be avoided by the use of an internal feed pipe which does not discharge into the water leg.

b It is the opinion of the Committee that such a method of delivery of feedwater to a vertical tubular boiler through an internal pocket or baffle above the water leg, with handhole opening for cleaning, is in full accordance with the requirements of the Boiler Code.

CASE NO. 275

Inquiry: Is autogenous welding permissible for the longitudinal joint of the fire box of a form of vertical boiler as shown in Fig. 3, where the furnace section is, after welding, heated and corrugated by rolls? The corrugations are rolled to a depth of 1½ in. on 8 in. centers, and the weld shows no fracture or distress after either corrugating or flanging.

Reply: It is the opinion of the Committee that the construction referred to fully complies with the requirement of Par. 186

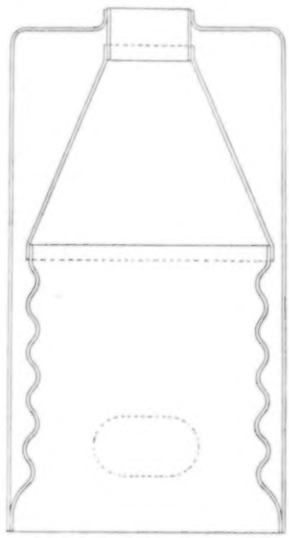


FIG. 3 VERTICAL SINGLE-FLUE BOILER WITH CORRUGATED FIRE BOX

of the Boiler Code, and the thickness of the furnace for a given maximum allowable working pressure should be determined in accordance with Par. 243.

CASE NO. 278

Inquiry: What would be considered the lowest permissible water level for a vertical water-tube boiler of the type shown in Fig. 4? Par. 430*e* of the Boiler Code to which reference is made

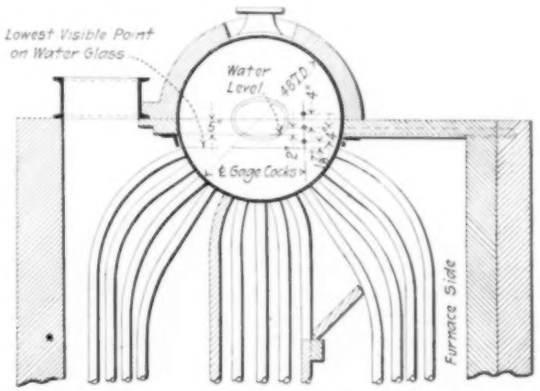


FIG. 4 LOCATION OF THE LOWEST PERMISSIBLE WATER LEVEL

in Par. 291 relative to the lowest permissible water level, leaves the location rather problematical as there may be a difference in opinion as to what the lowest permissible water level may be.

Reply: It is the opinion of the Committee that for a water-tube boiler of the design illustrated, a location for the lowest permissible water level such as referred to in Par. 430 *i* would be a suitable and safe construction.

CASE NO. 283.

Inquiry: In the construction of a water-tube boiler in which the tubes enter the tube sheet at an angle as great as 20 deg. from the normal, may the requirements of Par. 252 of the Boiler Code be fulfilled if the least projection of the tube be not less than ¼ in., or more than ½ in.?

Reply: It is the opinion of the Committee that Par. 252 applies to tubes which enter normally to the sheet and that where

the tubes are at an angle, the least projection of the tube should be not less than ¼ in. or more than ½ in., which may result in the tube projecting more than ½ in. at other points around the tube. The rule given in Par. 251 for flaring should apply to the true diameter of the tube hole measured in a plane at right angles to the tube end and not to the maximum diameter of the elliptical opening in the tube sheet.

CASE NO. 287

Inquiry: Is it permissible to burn off the edges of boiler plates and use them without any finish where sheared edges would be permitted by the rules in the Boiler Code?

Reply: The Code does not prohibit the practice suggested.

CASE NO. 288

Inquiry: Where a manhole is applied to the head of a dome and an opening for access to the boiler is placed in the shell under the dome, is it necessary to reinforce this opening in accordance with the requirements of Par. 260?

Reply: It is the opinion of the Committee that such an opening should be reinforced in accordance with the requirements of Par. 260. The reinforcing effect of the base of the dome may be included in calculating the reinforcement.

CASE NO. 291

Inquiry: In the case of a special arrangement of spacing of tube holes in the shells of the drums of a water-tube boiler with the pitch unequal in every second row, but shifting the adjoining rows to an exact stagger as shown in Fig. 6, is it

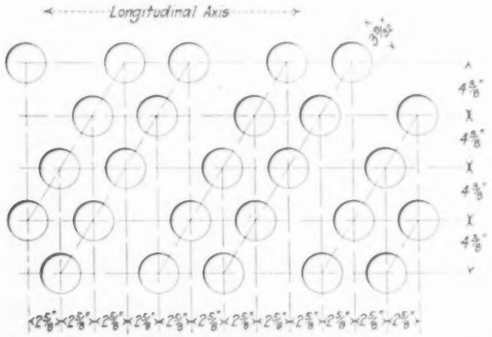


FIG. 6 SPECIAL SPACING OF TUBE HOLES IN DRUM OF WATER-TUBE BOILER

proper to calculate the efficiencies of ligaments under the requirements of Pars. 192 or 193 of the Boiler Code?

Reply: It is the opinion of the Committee that the efficiency of the tube sheet should be obtained by employing the method outlined in Pars. 192 and 193 of the Code for diagonal ligaments. All possible methods of failure should be assumed and the lowest value obtained through any one of the methods, should be used.

CASE NO. 292

Inquiry: In the case of a triple-riveted butt and double strap joint with the pitch of rivets in the first and third rows one-half of that of the second row, as shown in Fig. 7, what is the proper method of determining the back pitch between the first or inner and second or middle rows of rivet holes?

Reply: It is the opinion of the Committee that the back pitch required between the first or inner and the second or middle rows of rivet holes in such a design of joint, shall be governed by the rules of Par. 182 for determining the back pitch between the second and third or outer rows of rivets.

CASE NO. 293 (In the hands of the Committee)

CASE NO. 294

Inquiry: Is it the intent of Par. 331 of the Boiler Code that at least one complete set of the four stamps specified for boiler plate in Par. 36 remain visible after the completion of the boiler, or if the slab or melt number is invisible, are the remaining markings sufficient to meet the Code requirements?

Reply: It is the opinion of the Committee that all of the information which the Code requires to be stamped on the plates at the mills must be obtainable from the finished drum structure for each plate. All four stamps need not be visible at a given point if the fragments from various sets can be pieced together so as to give the desired information.

CASE NO. 295

Inquiry: How may an inspector in the field know the range of tensile strength of boiler plate?

Reply: Attention is called to the fact that the range for all classes of steel specified in the Code is 10,000 lb. per sq. in. and the tensile strength stamped on the plate indicates the minimum of this range, which minimum under the rules must not exceed 55,000 lb. per sq. in.

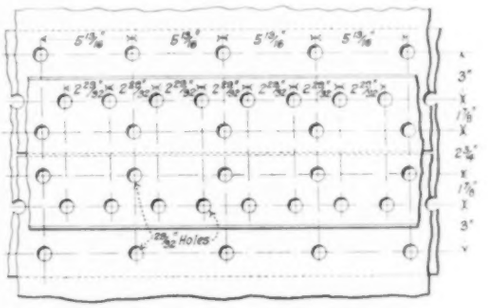


FIG. 7 TRIPLE-RIVETED JOINT WITH WIDE RIVET SPACING IN INNER ROWS

CASE NO. 296

Inquiry: Will a water-tube boiler of a type largely used in marine service, the heating surface of which is constructed mainly of iron pipe screwed into malleable iron and steel fittings, meet the requirements of the Boiler Code, if the pipe used is a special quality of redrawn lap-welded iron pipe of puddled stock and tested to 1000 lb. hydraulic pressure?

Reply: There is nothing in the Boiler Code to cover the use of iron pipes for the tubes of such a boiler with screwed joints. Until such a time that the specifications for piping have been formulated, the Boiler Code Committee would consider that if the other requirements of the Boiler Code are met, special redrawn pipe not to exceed 1½ in. standard pipe size made from lap-welded iron of puddled stock and tested to 1000 lb. hydraulic pressure, may be used for a working pressure not to exceed 200 lb. per sq. in., provided the wall thickness is at least 50 per cent greater than the wall thickness required by the Code for tubes of water-tube boilers.

CASE NO. 297

Inquiry: Will the requirements in the Boi'er Code for automatic water gages be met under the terms of Par. 427*e*, if the shut-off valve in the upper fitting has a projection which pushes the ball away from the seat for a distance of ⅛ in., causing the ball to drop to a position considerably greater than ¼ in. away from its seat?

Reply: It is the opinion of the Committee that the intent of the requirements of the Code will be met in the construction described.

CASE NO. 298

Inquiry: Is it permissible in the case of a forged steel steam outlet riveted to the boiler shell to use a wrought steel flange screwed to the outer end of the endneck, the neck being properly threaded and peened over into a beveled part cut away from the flange?

Reply: It is the opinion of the Committee that this method of forming a steam outlet connection meets the requirements of the Rules in the Boiler Code.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of MECHANICAL ENGINEERING by members of The American Society of Mechanical Engineers are solicited by the Publication Committee. Contributions particularly welcomed are suggestions on Society Affairs, discussions of papers published in this journal, or brief articles of current interest to mechanical engineers.

Simplification of Venturi-Meter Calculations

TO THE EDITOR:

In regard to my article on the above subject in the April issue of MECHANICAL ENGINEERING and Mr. C. G. Richardson's comments in the May issue, I wish to state the following:

Mr. Richardson is probably entirely right in his statement regarding the drop which should take place across a well-designed and constructed venturi meter. As I was not interested particularly in this drop at the time of making the experiments referred to, I took no pains to measure it accurately and the 2½ in. drop mentioned was not intended to be more than an approximation.

Mr. Richardson's statement as to the permissible ratio between the pressure at the throat and the initial pressure being as low as 0.84 is of course correct, but I would not advise designing a venturi meter having such a ratio of pressure at its rated capacity, inasmuch as any flow in excess of such rated capacity would increase this ratio to such an extent that it would probably go beyond the range of the pressure-measuring apparatus used in conjunction with the meter, whereas if a meter is designed for its rated capacity with the ratio nearer 0.90, it will be possible at times to exceed this flow without increasing the pressure differences very greatly out of proportion to the increase of the flow.

The tabular values of the function of P_2 and P_1 were plotted out to a very large scale for use during the experimental work and are shown in my article only to a reduced scale.

GLENN B. WARREN.

Schenectady, N. Y.

Industrial Training in China

TO THE EDITOR:

The letter appearing on page 305 of MECHANICAL ENGINEERING for May 1920, entitled Industrial Training in China, is of great interest to me, not only on account of my three years as a university professor in China, but because I am generally interested in relations between China and the United States. Mr. Foster has a distinct end in mind, namely, the encouraging of American manufacturers to supply mechanical equipment for schools in China, but in the course of making his argument, quite inadvertently no doubt, he presents a somewhat inaccurate picture of the present status of technical education in China. I am very sure the general reader of his letter will get the impression that there are no technical schools in China worth mentioning, except Peking University. The name of the latter is incorrectly given, by the way, Peking University being a Methodist school which, so far as I know, has never given any engineering courses. The writer doubtless has in mind the Peking Union University, which is just being organized and therefore has its record to make as far as technical education is concerned. On the other hand, there have existed in China for a number of years technical schools that of course have their drawbacks but which on the whole compare very favorably with the state colleges of the less populous states of the West. As to the character of work done, to cite a specific instance, the graduates of Pei Yang University in engineering have in the past found no difficulty in entering American universities of the first class as graduate students and taking their master's degree in one year and their doctor's degree in two years.

I am glad to be able to say that in the majority of cases the instructors in these schools have been Americans and that in nearly all instances they are of a grade that will compare favorably with those in American colleges.

The present situation in regard to the tendency of Chinese students to go to France rather than the United States is even more serious than Mr. Foster indicates in his letter, and it is highly desirable that an effort should be made to promote both the coming of Chinese students to the United States for study and the study of engineering in China.

T. T. READ.

Washington, D. C.

Technical Library Book and Journal Indexing

TO THE EDITOR:

I have just read an abstract of a report made by Mr. Harrison W. Craver, Director of the U. E. S. Library Board.

As one who is much interested in the entire subject and more distinctly so in certain phases, I am pleased to be at one with Mr. Craver in his advocacy of the Dewey Classification and its later extension, the Brussels Classification, and for the same reasons that Mr. Craver has so well expressed.

Mr. Craver states that "the catalog cannot be expected to act as an index to all the books in the library." Undoubtedly this is correct as applied to the present books with their present indexes, but I hope that the time will arrive when all books and all technical journals will be indexed by the same method that is suggested for the books in the library. When that time arrives the book or journal indexes will be logical extensions in detail of the general library index. Nor is this by any sense a utopian dream. The Dewey or Brussels Index is, in actual practice, so simple that it would require probably less time than the preparation of the usual indexing method employed.

Before I advocated this to the publishers of certain technical journals I tried it out myself and made up an extensive index covering the automotive industry in detail. This and the existing Dewey Index applying to mechanical subjects I applied to a year's issue of certain automobile publications and to a year's issue of the *American Machinist*. I found that the entire work occupied less than one-half hour's time daily for a week. Surely an index of this character will be far more useful than the usual haphazard one now found in technical journals under names or titles that have frequently no relationship whatever to the subject itself. The situation is not quite as bad in most technical books, but it is bad enough.

Those engineers who realize that much useful information is to be found in the technical journals which rarely or very late finds its way into books, and who therefore collect such data, would find their task enormously facilitated by the adoption of this indexing method. This work would be further facilitated if they would secure duplicate copies of the journals that they find most useful, in that they could then gather all of the information contained under any given index number in a group and so file it without the necessity of destroying part of any article that might happen to be closely printed with another article under another index number.

The adoption of this plan would also make technical journals much more useful in a library such as the United Engineering Societies Library, in that the index of each journal would be a logical continuation of the Library's index.

It is to be hoped that Mr. Craver will use his and the United Engineering Library's undoubtedly very great influence with publishers and editors to adopt this plan in their own interest as well as the interest of the Library and that of the users of books and journals.

Philadelphia, Pa. HENRY HESS.

MECHANICAL ENGINEERING

THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Published Monthly by the Society at
29 West Thirty-ninth Street, New York

FRED J. MILLER, *President*

WILLIAM H. WILEY, *Treasurer* CALVIN W. RICE, *Secretary*

PUBLICATION COMMITTEE:

GEORGE A. ORROK, *Chairman* J. W. ROE
H. H. ESSELSTYN GEORGE J. FORAN
RALPH E. FLANDERS

PUBLICATION STAFF:

LESTER G. FRENCH, *Editor and Manager*
FREDERICK LASK, *Advertising Manager*
WALTER B. SNOW, *Circulation Manager*
136 Federal St., Boston

Yearly subscription $4.00, single copies 40 cents. Postage to Canada, 50 cents additional; to foreign countries $1.00 additional.

Contributions of interest to the profession are solicited. Communications should be addressed to the Editor.

Those of us who dwell in the past must have memories, enjoyable and fine. With generous, engineering comradery and unbounded St. Louis hospitality we may build a memory of the 1920 Spring Meeting of the A.S.M.E. that will long stand.

The short elapsed time does not allow us to record the parts of the meeting that years from now will remain in mind; but so successful was the well-planned and carefully-executed program of the St. Louis meeting in its appeal to both old-timer and novice that material for memory building abounds.

As suggestions, think of any of the interesting plants visited, recall the beautiful Shaw's garden, the picturesque open-air theater, the jolly ride up the river, or the quiet talk of experience and mutual confidence with an old friend and the making of several new friends. Whatever the individual reason, St. Louis will always be remembered as the place of a wonderfully successful Spring Meeting.

The Federated American Engineering Societies

The outstanding event of the past month has been the conference in Washington of the representatives of about seventy-five (75) of the leading national, regional and local engineering and allied technical organizations.

This conference was the culmination of the work of several committees in the local and national societies during the past few years, resulting in a joint conference committee of the four national engineering societies of Civil, Mining and Metallurgical, Mechanical, and Electrical Engineers.

To say that the conference was a complete success does not begin to describe it; the get-together movement of the professional men in engineering, architecture, chemistry and allied professions is an accomplished fact.

Interest was keen from the minute the conference opened until it closed with inspiring addresses from such men as Homer L. Ferguson, Past-President of the United States Chamber of Commerce; Robert S. Woodward, President of the Carnegie Institution; and James R. Angell, Chairman of the National Research Council.

The reason for the success was the sincere desire of all the delegates to subordinate personal interest, even of the organizations which they represented, to the common good. And the cause of the common good was expressed more fully and perfectly than I have ever yet heard it expressed: *"Service to others is the expression of the highest motive to which men can respond and duty to contribute to the public welfare demands the best efforts that men can put forth. Therefore, it shall be the object of this organization to further the interests of the public through the use of technical knowledge and engineering experience, and to consider and act upon matters common to the engineering and allied technical professions."*

In the long run, success not only of individuals but of organizations is dependent upon the fundamental motive's being unselfish. This is not inconsistent with the greatest possible personal rewards, both to individuals and to groups, which are the natural result of the indispensable services rendered. In other words, the man who can produce the greatest results is the man who can command a high salary. When engaging a man absolutely indispensable to the success of any given enterprise, one of the commonest inducements is that "salary is no object."

With the splendid spirit which actuated the entire conference, the Joint Conference Committee was invited by the delegates to arrange for a fall meeting to complete the organization, the constitution and by-laws having been adopted. In the meantime, until the perfection of the new organization, the Engineering Council was invited to continue to conduct the work which it has started and to take up any other matters which should be acted upon by the Federated American Engineering Societies when that body shall be organized.

With good generalship, the members of Engineering Council (of which there were a goodly number present, in their capacity as members or representatives of some of the societies) secured from their body a formal invitation to all of the organizations represented at the Washington Conference to attend by delegate the next meeting of Engineering Council, on which occasion such delegates would be accorded the privileges of the floor and participation in all debate.

One of the officers of one of the leading foundations is obligated among his duties to investigate and report on all organizations conducted under national, state or municipal auspices. And I firmly believe that if this officer were to investigate in the same manner the Federated American Engineering Societies and reflect on its objects he could report that it is destined to be one of the most useful of organizations—that everyone working with it, whether by serving on its committees or otherwise, will be inspired to give his best to the nation and to the community in which he lives and thus enhance the standing of his profession.

CALVIN W. RICE,
Secretary.

Plain Limit Gages for General Engineering Work

The new Sectional Committee of The American Society of Mechanical Engineers recently organized to undertake the standardization of plain limit gages held its organization meeting in the rooms of the Society on Friday, June 11. The Committee met as a whole in the morning and divided into sub-committees for the afternoon session. As a result it has already mapped out its work for the next three months.

This Committee, as will be recalled, was organized by the Society at the request of the American Engineering Standards Committee, and it is planning to coöperate with a similar committee recently organized by the British Engineering Standards Association. The personnel of the Committee is as follows:

E. C. PECK, *Chairman*, Gen. Supt., Cleveland Twist Drill Co., Cleveland, Ohio.
L. D. BURLINGAME, *Vice-Chairman*, Industrial Supt., Brown & Sharpe Mfg. Co., Providence, R. I.
H. W. BEARCE, *Secretary*, Gage Dept., Bureau of Standards, Secy. National Screw Thread Commission, Washington, D. C.
P. W. ABBOTT, Lincoln Motor Company, Detroit, Mich.
JOHN BATH, President, John Bath & Co., Inc., 8 Grafton St., Worcester, Mass.

EARLE BUCKINGHAM, Engineer of Standards, Pratt & Whitney Company, Hartford, Conn.
FRED H. COLVIN, Assoc. Editor, *American Machinist*, 10th Ave. & 36th St., New York City.
W. A. GABRIEL, Ch. Draftsman and Designer, Elgin National Watch Co., Elgin, Ill.
F. O. HOAGLAND, Vice-Pres. & Works Mgr., The Bilton Machine Tool Co., Bridgeport, Conn.
EDWARD H. INGRAM, Works Manager, The Cleveland Milling Machine Company, Box 350, Cleveland, Ohio.
J. O. JOHNSON, Major attached to office of Chief of Ordnance, War Department, Washington, D. C.
A. W. SCHOOF, Gage Engineer, Greenfield Tap & Die Corporation, Greenfield, Mass.
G. T. TRUNDLE, Consulting Engineer, Engineers' Building, Cleveland, Ohio.
H. L. VAN KEUREN, The Van Keuren Company, 362 Cambridge Street, Boston, Mass.

Swiss Mission to Study American Economic Conditions

The group of Swiss engineers, architects, manufacturers, merchants, and agriculturists known as the Swiss Economic Mission, arrived in New York on May 27. The fact that this organization intended to visit this country to study economic conditions here was made known to the Society last autumn by the Hon. Hans Sulzer, of the Swiss Legation of Washington, D. C. The members, although not official representatives of the Swiss government, are progressive professional men of eminence.

The fact that Switzerland feels its indebtedness to this country for its supply of foodstuffs, especially cereals, during the war, was expressed by Professor Hilgard, of Zurich, at a dinner given to the entertainment committees of the American Society of Civil Engineers and The American Society of Mechanical Engineers at the Hotel Pennsylvania, June 3.

The party has been conducted on a general sight-seeing tour throughout the eastern and central sections of the country, with a brief stay in Canada. The entertainment for the mission was largely arranged for by the Local Sections of the A. S. M. E. in conjunction with the local chambers of commerce of the various cities visited. The party will sail for Liverpool on or about July 5.

Austrian Engineers Appeal for Help

The Austrian Society of Civil Engineers and Architects, through its president, secretary and editor, has appealed to The American Society of Mechanical Engineers for relief for about 500 of the 4000 members who are without occupations and who are in distress.

Under the plan through which food drafts are sent to Austria through the American Relief Administration, 115 Broadway, New York City, the Austrian society is ready to deposit at a bank a sum in Austrian crowns equivalent to six times the present exchange for every dollar sent by Americans. This organization is further ready to distribute food not only among its own members but among all Austrian technical men who may call for help.

The Council of the A.S.M.E. received this appeal at its last meeting and refers it through the columns of MECHANICAL ENGINEERING to those of the members who may wish to extend succor by sending food drafts.

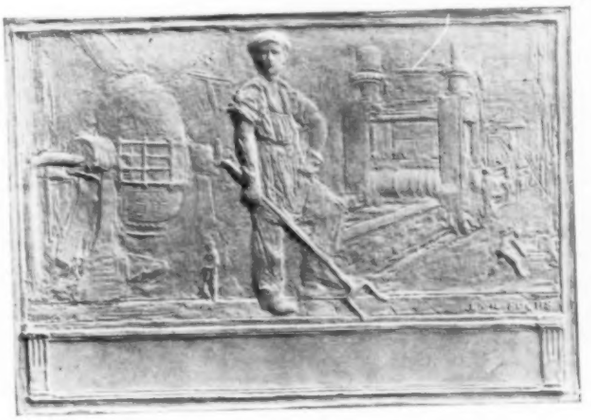
Drafts may be obtained at any bank in this country and should be made available to the Austrian Society of Civil Engineers and Architects, Wien, 1, Eschenbachgasse 9, mailing them to the American Relief Administration. This system of food drafts is apparently very sure and any member sending help in this manner may be certain of its receipt.

The Robert W. Hunt Medal Fund

The eightieth birthday of Captain Robert W. Hunt was commemorated by the American Institute of Mining and Metallurgical Engineers by the presentation to him of the Hunt Medal for meritorious contributions to the art of making steel. The medal was designed and executed by Emil Fuchs, a medalist of international fame, and is considered, both from the point of execution and of symbolic significance, one of the most beautiful of any connected with the engineering profession.

The presentation ceremony took place on May 27 in the auditorium of the Engineering Societies Building. A. A. Stevenson opened the meeting and introduced John J. Cone, one of Captain Hunt's partners, who gave an account of the captain's career and his notable contributions to steel metallurgy. He then presented to the Institute on behalf of the associates and

employees of Captain Hunt the Robert W. Hunt Fund, which consists of $7500, as an endowment fund to provide an annual award, and $1000 for the expenses of providing the medal. Herbert Hoover accepted the Fund on behalf of the Institute and, following a short speech by Charles M. Schwab, announced that



the Iron and Steel Committee had awarded the first medal to Captain Hunt himself for his contributions to the steel industry, particularly the development of the steel rail. The ceremonies closed with a short speech of acceptance by Captain Hunt.

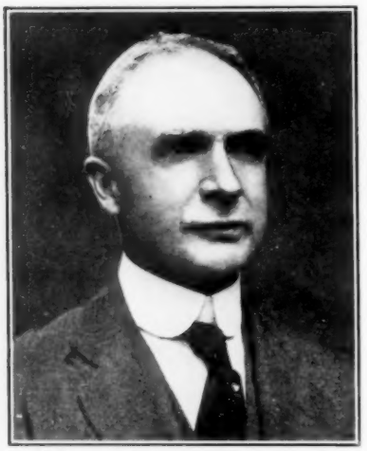
Slow Delivery of Mechanical Engineering Bulletin

The U. S. Post Office Department threw in low gear in the distribution of the "Mechanical Engineering Bulletin" issued to the A.S.M.E. membership in May. This bulletin was planned by the Sections Committee of the Society with the expectation that it might be issued at intervals and give prompt service in respect to Employment Bulletin items and important news notes. That the "prompt service" idea was missing in this first issue, at least in some cases, is evident from the fact that copies were not received in Cleveland until three weeks after the mailing date (May 19). This is an example of the many difficulties now experienced by those who are sending out large quantities of second and third-class mail matter. If it should be decided to continue the bulletin, the most that can be said is that we hope the Post Office Department may gradually get back into high-gear operation.

Organizing Conference Plans Federation of Engineering Societies

Delegates from 71 Engineering Organizations and Allied Technical Societies Adopt Constitution Creating "The Federated American Engineering Societies"—New Organization to Represent Profession in Matters of Common Concern and in National and State Affairs

IN a two-days' conference at Washington, D. C., June 3 and 4, which was marked by the intense enthusiasm of the attending delegates, the representatives of 71 engineering and allied technical societies took the first step toward the creation of an organization which should speak with a single voice for the engineering profession of the United States. This Organizing Conference, as it was known, was called by the Joint Conference Committee of the Four National Engineering Societies, who for some time past have been concerned with the problem of democratization of the profession and of effecting a closer coöperation between existing engineering and allied technical organizations. The conference thus called was a success in the highest degree, for with a fine disregard of unimportant details it adopted a constitution and by-laws of an organization to be known as "The Federated American Engineering Societies," a body composed of national, local, state, and regional engineering organizations which is to function through an "American Engineering Council."



CALVERT TOWNLEY
Chairman of the Conference

The opening session of the conference was called to order by Richard L. Humphrey, of the American Society of Civil Engineers, the chairman of the Joint Conference Committee. He reviewed the history of that committee and explained the basis of representation of delegates at the conference. He also spoke briefly of the need of a federation of engineering societies and of the value to the profession of such a body. Following Mr. Humphrey, Lt-Col. C. W. Kutz, U. S. A., engineer commissioner of the District of Columbia, welcomed the conference on behalf of the engineering societies of Washington.

The delegates then proceeded with the election of officers and Calvert Townley, past-president of the American Institute of Electrical Engineers, was chosen chairman, and John C. Hoyt, of the American Society of Civil Engineers, secretary. Dr. F. H. Newall, of the American Association of Engineers, then presented a resolution to the effect that the delegates of the conference have the full power to make rules governing its procedure. He also suggested that the conference proceed at once with the business of the day rather than adhere to the program as arranged by the committee. To these suggestions the conference readily assented.

Major G. S. Williams, of the Grand Rapids Engineering Society, thereupon at once offered the following resolution:

Resolved, That it is the sense of the convention that an organization be created to further the public welfare wherever technical knowledge and engineering experience are involved and to consider and act upon matters of common concern to the engineering and allied technical profession; and

Resolved, That it is the sense of this convention that the proposed organization should be an organization of societies or affiliations and not of individuals.

This resolution was at once seconded and a spirited debate immediately ensued. The representatives of the American Associations of Engineers were the first to discuss the resolution. They argued for the creation of an organization composed not of societies or affiliations but of individuals, and they pointed out the advantages such a society would have for the individual engineer. They urged that their association be made the medium through which the entire engineering profession should speak in matters of federal and state concern and they appealed to all engineers to join their ranks.

Following the delegates of the American Association of Engineers, the representatives of the large national and the smaller local and regional organizations expressed their opinion as to the resolution, and it soon became evident that the conference was overwhelmingly in favor of a federation of existing societies and not of accepting any existing society to represent them nor of the formation of a new society composed of individuals.

The delegates who spoke in favor of the resolution urged its passage upon the grounds that an organization of organizations was the great need; a body which could represent the profession in such matters as concerned it as a group and not as individuals, as the interests of the individual, they claimed, were being well cared for by the existing national and local societies. The small local societies, particularly, were uniformly in favor of the resolution, and their representatives pointed out the value of a central organization through which they might be represented in federal and state matters, in which at the present time they are unable to participate.

When the resolution was put to vote, the societies voted in the order of their arrangement on the program, which was an alphabetical one. This placed upon the American Association of Engineers the necessity of voting first, and although they had argued against the resolution, nevertheless, sensing the wishes of the majority, they announced that their seventeen delegates voted aye. This announcement came as a great surprise to the conference, who at once voiced their approval by hearty applause. As the balloting continued it became evident that the resolution would easily pass, and when the secretary announced the final vote it showed that 119 delegates had voted aye, none had voted in the negative, and of the 71 societies present only five had not voted. This important decision of the conference taken so soon after it had convened showed the intense interest of the delegates in the movement and made clear their ability to act along broad, general lines without allowing themselves to be confused with details. The passage of the Williams resolution established beyond doubt the ultimate success of the movement and marked the first step toward the creation of the new organization.

JOHN C. HOYT
Secretary of the Conference

Following the vote on the resolution, Chairman Townley appointed three committees to deal with the details arising in connection with the conference. These were committees on constitution and by-laws, resolutions, and program. R. L. Humphrey was appointed chairman of the constitution and by-laws committee; Philip N. Moore, chairman of the resolutions committee; and

Robert H. Fernald, chairman of the program committee. These committees at once retired and the conference proceeded with the program as arranged by the Joint Conference Committee. This included addresses on the Functions of the Engineers in Public Affairs, by Arthur P. Davis, president of the American Society of Civil Engineers; Philip N. Moore, past-president of the American Institute of Mining and Metallurgical Engineers; and Leroy K. Sherman, president of the American Association of Engineers.

On Friday morning the conference began a consideration of the constitution and by-laws as prepared by the committee appointed the day previous. These were presented by Richard L. Humphrey, chairman of the committee, and after considerable discussion of their many details, both constitution and by-laws were passed in very nearly the same form as received from the committee. The vote on the constitution was particularly interesting in that it was indicative of the probable participation of the various societies in the new movement. Eight societies went on record as "present but not voting," among them being the American Association of Engineers. The final vote showed 88 delegates casting affirmative votes, ten absent and none against.

Following the announcement by Chairman Townley of the passage of the constitution and by-laws, L. P. Alford, chairman of the delegation representing The American Society of Mechanical Engineers, announced that the delegates who represented the Society were empowered to commit the organization, and that as soon as The Federated American Engineering Societies were ready to receive applications The American Society of Mechanical Engineers would apply for membership. The Society is thus the first organization to join the new movement.

The constitution, in accordance with the instructions of the conference, is now in the hands of an editing committee, and later MECHANICAL ENGINEERING will present it in its complete and finished form. The main features of the Constitution are:

Membership. Membership is to consist of national, local, state and regional engineering and allied technical organizations and affiliations, classified as follows:

(1) National engineering and allied technical organizations
(2) Local, state, or regional engineering or allied technical organizations other than local associations, sections, branches or chapters of national organizations
(3) Affiliations consisting of local sections of national organizations, local engineering societies or clubs and local engineers.

Management. The management of the new organization is to be vested in a body known as the American Engineering Council and its Executive Board. This Council is to consist of representatives of member societies each of which shall be entitled to one representative for a membership of from 1 to 1000, and one additional representative for each additional thousand members or a major fraction thereof. This Council is to hold an annual meeting. The elected officers of the Council will be a president, to hold office for two years, four vice-presidents, to hold office for two years, and a treasurer, to hold office for one year. An executive officer who shall also be secretary is also provided. The Executive Board is to consist of thirty members of the Council, and this Board is to conduct the business of the new organization under the direction of the Council. The six officers selected by the Council are to be members of this Executive Board, and the balance of twenty-four shall be selected by the National Societies and local, state and regional organizations according to districts. The president and secretary of the Council shall be, respectively, the chairman and secretary of the Executive Board.

Funds. The funds for the use of the new organization are to be obtained in the following manner: Each national member society represented on the Council is to contribute annually $1.50 per member. Each local, state or regional organization represented is to contribute annually $1 per member.

Local Affiliations and State Councils. The Council is empowered to encourage the formation of local affiliations to consider matters of purely local public welfare with which the engineering profession is concerned. It is also authorized to create state councils consisting of representatives of the local affiliations within the state. These councils are also for the purpose of considering matters of public welfare as associated more particularly with state matters.

Evening sessions were held at the New Willard Hotel on both days of the conference. On Thursday evening the delegates were addressed by Homer L. Ferguson, past-president of the United States Chamber of Commeree; James H. McGraw, president of the McGraw-Hill Publishing Co. of New York; and George Otis Smith, director of the United States Geological Service, Washington, D. C. On Friday evening addresses were given by Samuel M. Vauclain, president of the Baldwin Locomotive Works, Philadelphia, Pa.; Robert S. Woodward, president of the Carnegie Institution, Washington, D. C.; and James R. Angell, chairman of the National Research Council, Washington, D. C. All of these addresses were highly inspirational to the delegates assembled, and it is to be regretted that space will not afford even a brief comment on them. E. W. T.

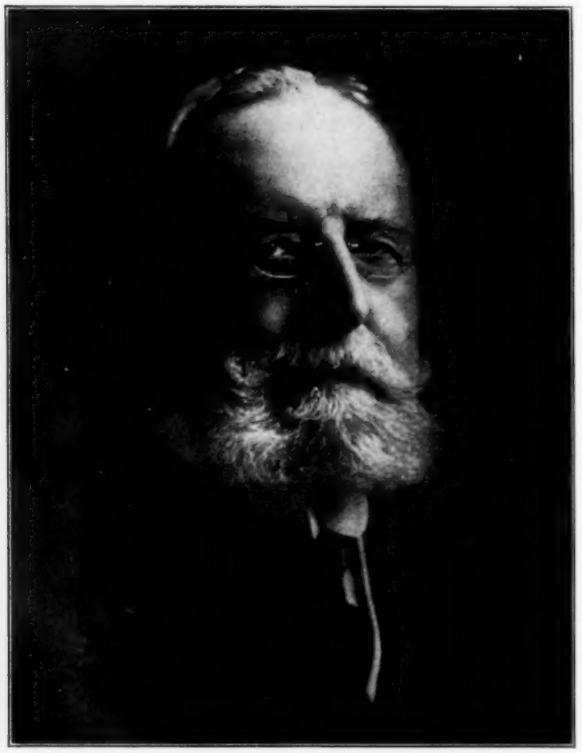
ORGANIZATIONS PARTICIPATING IN CONFERENCE

American Association of Engineers
American Association of Petroleum Geologists
American Ceramic Society
American Concrete Institute
American Electric Railway Engineering Association
American Electrochemical Society
American Institute of Electrical Engineers
American Institute of Mining and Metallurgical Engineers
American Ordnance Association
American Railway Engineering Association
American Society of Agricultural Engineers
American Society of Civil Engineers
American Society of Heating and Ventilating Engineers
American Society of Mechanical Engineers
American Society of Naval Architects and Marine Engineers
American Society of Refrigerating Engineers
American Society of Safety Engineers
American Society for Testing Materials
American Water Works Association
Associated Engineering Societies of St. Louis
Associated Engineers of Spokane
Association Railway Electrical Engineers
Boston Society of Civil Engineers
Brooklyn Engineers' Club
Cleveland Engineering Society
Colorado Society of Engineers
Connecticut Society of Civil Engineers
Detroit Engineering Society
Duluth Engineers' Club
Engineers' and Architects' Club of Louisville
Engineers' Club of Baltimore
Engineers' Club of Columbus
Engineers' Club of Minneapolis
Engineers' Club of Philadelphia
Engineers' Club of St. Louis
Engineers' Club of Trenton
Engineering Council
Engineering Society of Akron
Engineering Society of Buffalo
Engineers' Society of Pennsylvania
Engineers' Society of Western Pennsylvania
Florida Engineering Society
Grand Rapids Engineering Society
Illinois Society of Engineers
Illuminating Engineering Society
Indiana Engineering Society
Institute of Radio Engineers
Iowa Engineering Society
Kansas Engineering Society
Los Angeles Joint Technical Society
Mining and Metallurgical Society of America
Minnesota Surveyors' and Engineers Society
Mohawk Valley Engineers' Club
Nashville Engineering Association
National Fire Protection Association
National Safety Council, Engineering Division
New England Water Works Association
Oregon Technical Council
Providence Engineering Society
Scientech Club
San Francisco Joint Council of Engineering Societies
Society of American Military Engineers
Society of Automotive Engineers
Society of Engineers of Eastern New York
Society of Industrial Engineers
Society for the Promotion of Engineering Education
Taylor Society
Technical Club of Dallas
Topeka Engineers' Club
Vermont Society of Engineers
Washington Society of Engineers

EDMUND GYBBON SPILSBURY

ON May 20, 1920, Edmund G. Spilsbury, mining and metallurgical engineer of international reputation, died suddenly after many years of useful service to the profession and to the engineering societies.

Mr. Spilsbury was born in London, England, in 1845. He was educated in Belgium and was graduated from the University of Louvain in 1862. He then took up practical work in Germany, entering in 1864 the service of the Eschweiler Zinc Co., Stolberg, one of the largest miners and smelters of lead and zinc in the world. The following year he was given charge of that company's mines and works in Sardinia. In 1867 he became connected with McClean and Stillman, of London, in charge of the construction of the lock gates for the Surrey Commercial Docks; in 1868 he accepted the position of designing engineer with J. Casper Harkort and was assigned to the detail work of the Keulenberg Bridge in Holland, the Danube Bridge at Vienna and the



EDMUND GYBBON SPILSBURY

Rhine Bridge at Düsseldorf. Later he returned to the Eschweiler Company as chief engineer, and in 1870 came to the United States for the Austro-Belgian Metallurgical Co. to investigate the resources of this country in lead and zinc.

After two years in this country Mr. Spilsbury decided to take up practice here, in the course of which he introduced the Harz system of ore dressing for the zinc ores of Pennsylvania and New Jersey. During this period he was also engaged in explorations on the northern shore of Lake Superior and in Colorado, Montana, Utah and California. From 1873 to 1875 he was engaged as general manager of the Bamford (Pa.) Smelting Works; in 1879 he designed and built the Lynchburg Blast Furnace and Iron Works; he was also consulting engineer for the Coleraine Coal & Iron Co., Philadelphia. In 1883 he became general manager of the Hailer Gold Mine in South Carolina and in 1887 became connected with Cooper, Hewitt & Co., New York. From 1888 to 1897 he was managing director of the Trenton Iron Co., Trenton, N. J. While manager of these works he introduced as specialties of their business the Elliot locked wire rope and the Bleichert system of aerial tramways.

His practice as a consulting mining engineer and metallurgist took him into many parts of Europe, Africa, the United States, Mexico and South America. During the winter and early spring of 1920 he spent a number of weeks in Brazil on a mining project for clients in the United States and had returned to the United States only a few weeks prior to his death.

Mr. Spilsbury was the author of a number of important technical papers, mostly on mining processes and on mine appliances. He also wrote entertainingly in a lighter vein, and the following paragraphs from "Technical Reminiscences," published in *Mining and Scientific Press* in 1915, recall early interesting experiences.

Early pioneer work in Sardinia was most interesting and instructive. In the first place, the island was almost as much a terra incognita as our own West a century ago. And yet the civilization of Sardinia was one of the oldest in the world. The Phoenicians, the Egyptians, and later the Carthaginians and the Romans, had all left their marks, in old excavations, dumps, slag piles and more especially in the tombs cut out of solid rock. In the early 60's the northern and eastern parts of the island were dangerous, as well as difficult of access. The tribes occupying this mountainous district did not recognize the Italian Government and were generally classed as bandits. During the second year of my stay one evening I heard a disturbance outside my camp and the clatter of a number of horses. Thinking that I was about to be raided by the bandits, I called the two foremen who were in the house and, getting our guns, we started to see what the trouble was. Opening the door, I saw a small cavalcade. The leader was a very tall and slim young gentleman, dressed in full hunting costume. He addressed me by name, stating that he had a letter of introduction and asking if he and a friend could stay the night. I thought I had never seen a taller or lankier fellow, but withal, a most pleasant face. He handed me a letter from one of the directors of our company, asking me to make the stay of the bearer as pleasant as I could, as he was a friend of theirs, being the Duke of Brabant, afterward Leopold the Second, King of the Belgians. The Duke had come to Sardinia on a mountain sheep hunt. Years afterward, when he had succeeded his father, I always received a hearty welcome whenever I met him either in Brussels or Paris.

And again we find these paragraphs telling of the changes which have taken place in mining practice:

I wonder how many mining engineers of the present day can call to mind changes and advances in the practice of mining which have taken place in the last half century? Practically every appliance beyond the pick and shovel, hand hammer and drill, has been introduced during that short period. When I first started my practical course in underground work, we knew none of the aids now considered requisite to work economically. We had no machine drills to save the physical labor of hand work. Dynamite or its precursor, nitroglycerine, had not yet been invented; fuse was still unknown; even steel was more or less of a luxury, and our hand drills were still made of iron with steel bits welded on to them. The mushrooming of the head of the drill under the hammer blows was a constant source of trouble and injury to the hands of the miners. The only explosive known was the large-grained black powder.

It seems hardly credible today, and yet it is a fact that the contract price for driving or stoping ground was influenced by the condition of the rye crop. In seasons of drought, the height of the rye was much curtailed and the length of the straw between joints would be so short that the time occupied in jointing and filling the stalks which were used as fuses, greatly lessened the driving capacity of the miners. The straw primers naturally limited the possible depth of the hole and three feet was considered a good average. These straw fuses were very rapid and it was necessary to ignite them by a slow-burning sulphur wick.

Mr. Spilsbury was intensely interested in the work of the national engineering societies. He was a member of the American Institute of Mining and Metallurgical Engineers, of which he was president in 1896, the American Society of Civil Engineers, the Institution of Mining and Metallurgy of Great Britain, the Mining and Metallurgical Society of America, and the American Electrochemical Society; he became a member of The American Society of Mechanical Engineers in 1890. In 1916-17 he was president of the Engineers' Club of New York. He was a trustee of the United Engineering Society from 1916 until his death; a member of the Engineering Societies Library Board from its organization in 1913 and a member of the Engineering Foundation Board from 1916. He was also a member of the National Research Council. In all these associations he was an active and useful member and served on numerous committees and contributed freely of his time and ability.

Industrial Relations Association of America

Earnest Convention at Chicago Considers Vital Problems—"Educating with Truth" a Solution of Industrial Relations—Union Officials Boast of Increasing Production

THE Second Annual Convention of the Industrial Relations Association of America was held in Chicago at the Auditorium on May 19, 20 and 21. Organized in 1918 as the National Association of Employment Managers, its rapid growth and the appreciation of the breadth of the field led to the change in name.

To understand the spirit that permeated this gathering, one must picture one of the old-time preaching services lasting several days, people coming from all the countryside, listening to hour sermons with divine expectation, and sitting through long experience meetings, all in the hope of guidance in solving their daily problems. The Chicago convention of the I. R. A. A. was just such a meeting. Managers came to Chicago from east and west, from small plant and from large plant, 2500 in all, with a determination to absorb every portion of the great feast of information provided. Glimpses of receptive notebooks and poised pencils gave an impression accentuated by the earnest faces and quick shouts of "louder," if the speaker dropped his voice even momentarily, that these people were hard against the big problem in industry today, that of the relation of workmen and employer, and that they were seeking every atom of help from the knowledge and experience contributed at the convention.

The plan of the convention was based on the principle that every one of the twenty-five hundred in attendance should be given opportunity to check up his individual stock of experience with that of those attacking similar problems or engaged in similar industries. Thirty-three round-table subject luncheons were arranged at which topics such as Employment Office Methods, Radicalism, Americanization, Developing Plant Spirit, Housing and Introducing the New Worker, were considered under the guidance of capable leaders. At dinner those working in the same industry met for a consideration of the problems peculiar to that industry. The main sessions of the convention were given over to a treatment of the important phases of the industrial relations problem by well-known and properly equipped speakers.

In the opening address Cyrus H. McCormick, works manager of the International Harvester Co., laid down the principle that truth and its wide dissemination was the only firm basis on which lasting coöperation between employers and employees can be built. He stated the duty of the employment manager to be the education of the employees and emphasized the importance of the proper fulfilling of this duty.

Incentives and Their Relation to Production were discussed by L. C. Marshall, dean of the School of Commerce and Administration, University of Chicago, and Frank J. Raymond, of the Inter-Racial Council of New York.

The importance of having each workman understand the part he is playing in the complete scheme of manufacture and the effect of the individual's effort on the finished product, was handled by H. B. Bole, vice-president, Hydraulic Pressed Steel Co., Cleveland, and Harry N. Clarke, president, The Cort-e-Scope Co., Cleveland. They outlined methods successfully used in giving their men a perspective of the entire operation of their plants.

C. A. Lippincott of South Bend, Ind., told of the housing scheme developed by the Studebaker Co. as a solution of the problem of community conditions affecting labor stability. The Studebaker plan is to build the houses and sell them to their workmen, loaning the money without interest. Mr. Lippincott paid his respects to the professional uplifters with the words, "Man does not need a gratuity. The activities of some welfare associations seem to intimate to the person to whom so-called succor is to be given, that he is in the mire and needs uplifting, such as they only can render."

In her talk on the Status of Women in Industry, Mary Van Kleek of the Russell Sage Foundation scouted the idea that women should receive special treatment as a peculiar problem in industry and spoke forcefully in favor of considering women's place in every phase in industry. Treating the subject of employee representation, Miss Van Kleek pointedly questioned the exploitation of industrial representation as a means of forcing false ideas of loyalty down the throats of employees, and stated as her real opinion that representation honestly offered by the employer would have a wonderful effect in bringing out leadership and developing true democracy.

The vital problem of the foreman and his relation to the organization and to the workman received special consideration. Dudley R. Kennedy, of Philadelphia, formerly in charge of industrial relations at Hog Island, touched the spot in his talk: "It's high time we stopped blaming the Reds and the agitators for the prevailing conditions and hang the blame where it belongs. If the radicals can do more with our men in two hours at night than we can, having them at our command for eight hours a day, then something is radically wrong. The fault lies at the top. "Industry must open its books to the workers. Also we must equip our foreman to answer the absurdities of the soapbox orators. Production has fallen off, not primarily because of derelictions among the workers, but because leadership isn't present, and it is up to management to provide the leadership." Mr. Kennedy's talk was emphasized by Leroy Kramer, vice-president of the Willys-Overland Co., of Toledo, who said that the foreman must be closer to the management of the plant than he is, so that he may be in a position to give the workers the truth, rather than permit them to get half-truths or untruths from irresponsible agitators.

One of the peaks of enthusiasm of the convention was reached at the close of E. J. McCone's speech stating his position on the open-shop question. Mr. McCone, general manager of the Buffalo *Commercial*, recently testified before the Senate committee that every newspaper in the country, except three, are subject to censorship of the typographical union. His subject was Organized Labor in Industry, and he made the plea for democracy in unionism and the right of an individual to join a union or not.

Mr. McCone spoke with an eloquence and enthusiasm that, at his closing words, brought the convention to its feet with applause and cheers. Sidney Hillman, President of the Amalgamated Clothing Workers of America, speaking on the same subject, uttered a new note in the call of organized labor. He stated the principal question of the day to be, "Shall humanity be starved to death through lack of production?" and pleaded for an industrial relationship that will establish a coöperation leading to greater production. Mr. Hillman outlined the work his union had done in bettering the conditions of the workmen in the clothing industry and quoted one of the employers who admitted that the organization had increased production in his shop. In closing, he made an earnest plea for a careful study of the industrial situation by the best minds of the country so that decisions in the future would be based on facts rather than the opinions advanced by glib talkers.

Sherman Rogers, of New York City, a former lumber jack and a man who has spent his life with the workmen, testified that what the workman wanted most today was the truth. He expounded forcefully his theory that placing the cards flat on the table was the only way to settle present conditions and he illustrated, from his experience, how Bolshevism had been checked and strikes forestalled by plain statements of the facts in the case.

What the workman thinks about modern employment methods and welfare work was illuminatingly explained by Whiting Williams, of Cleveland, who told how he was treated when he doffed his white collar and was hired and fired in shops and factories throughout the country. Severe though his comments were on the way men are treated, they were justly and graciously received by the convention. He showed the importance of a broad

point of view in handling industrial relations and the necessity for dignifying the employment manager's job.

Broadly stated, according to the principal speakers the solution of the problem of satisfactory industrial relations lies along the open recognition by the employer that his leadership depends on the confidence he places in his men and in the way he takes his men into his confidence.

The convention relaxed from its inspiring work for one evening when it presented "An Industrial Jamboree," a satirical burlesque on the Second Industrial Conference. All the characters were represented and their testimony before the conference of disagreements brought peals of laughter from the convention.

Plant visitation trips included the Stock Yards, the International Harvester Co., General Electric Co., Illinois Steel Co. and other smaller plants that have achieved success with their industrial relations work. C. E. D.]

MOTOR GASOLINE FROM HEAVIER HYDROCARBONS

(*Continued from page* 402)

It is becoming the practice to utilize heavy distillates for the purpose of cracking rather than the residual oils. In this way the amount of coke produced during the operation is materially lessened. For example a heavy asphaltic oil may be distilled to coke at atmospheric pressure and certain of the distillates used for the purpose of cracking.

Composition and Refining of "Cracked" Distillates. Unrefined "straight run" or "natural" gasoline distillates are composed of varying proportion of paraffins, naphthenes, aromatics, small percentages of olefines and a quantity of organic nitrogen and sulphur compounds generally small, but depending upon the character of the original crude petroleum. Oxygen compounds such as naphthenic acids may also be present in traces. Some of the straight-run gasolines which have been secured where direct steam was used in the distillation process necessitate little or no treatment with sulphuric acid.

The gasoline distillates produced by "cracking" contain diolefines in addition to the compounds mentioned above while the proportions of aromatics are larger. Cracking in the vapor phase only, because of the higher temperatures generally employed, produces larger proportions of unsaturated hydrocarbons and aromatics than in the case of the pressure still.[18] Cracked distillates upon standing may separate a resinous product which is derived, no doubt, from the diolefines and possesses explosive properties when heated.[19] The disagreeable odor of these distillates is attributed by some to the unsaturated hydrocarbons, particularly the diolefines. Brooks and Humphrey,[20] however, record that this disagreeable odor is to be attributed more to the presence of organic nitrogen, oxygen and sulphur compounds.

Sulphuric acid acts both chemically and physically upon unrefined distillates, colloidal coloring matter being precipitated and dissolved by the acid, unsaturated hydrocarbons, nitrogen, sulphur, and oxygen compounds entering into reaction, the three last mentioned being by no means completely removed. The rise in temperature which is especially marked in the case of unrefined "cracked" distillates when treated with sulphuric acid is no doubt largely influenced by the diolefines. According to Brooks and Humphrey, the lower olefines react to form alkyl esters, tertiary and secondary alcohols, some polymerization also taking place. Above the hydrocarbon $C_{12}H_{24}$ polymerization takes place to form di- and tripolymers which contain but one double bond. Brooks and Humphrey also made the interesting discovery that the higher olefines such as those found in the residual oils and in lubricating oils are but slightly reactive with concentrated sulphuric acid. In the case of gasoline distillates these polymers dissolve mainly in the hydrocarbon layer, raising the final boiling point. Likewise, neutral esters of sulphuric acid remain in the gasoline and are not removed when the product is washed with alkali solution; upon standing the product is likely to precipate a resinous, viscous layer due to these esters.

It is well known that the "cracked" distillates are more difficult to refine successfully than the "natural" products. The loss is likely to be large and the resultant product may be colored. Ellis and Wells[19] report that by hydrogenation of "cracked" gasoline was secured a water-white product, but they do not give the specific method used nor the constants for the gasoline before and after treatment.

Brooks and Humphrey[20] recommend that the unrefined product be treated with not more than 6 per cent of 85 to 90 per cent sulphuric acid, followed by *redistillation.*

Experiments Undertaken by the Author. In order to determine practical refining conditions for "cracked" distillates, as far as *color, odor,* and *stability* are concerned, the writer and his students have carried out some experiments upon "cracked" distillates from commercial pressure stills. Constants on the unrefined pressure gasoline distillate and the natural gasoline distillate, both from the same crude petroleum mixture, were determined as follows:

	Crude Straight-Run Gasoline	Crude Pressure Still Gasoline
Gravity, deg. Bé	57.7	54.3
Refractive index	1.4142	1.4252
Heat of reaction with sulphuric acid (1.84 sp. gr.), deg. fahr.	1	11
Loss of sulphuric acid (room temp.), per cent	9	16
Loss of sulphuric acid (32 deg. fahr.), per cent	5	8

The experimental work undertaken upon the refining of cracked distillates has developed in such an interesting way that the work may be considered as only begun. The best results from the standpoint of both color and odor were secured by direct treatment of the pressure still gasoline with concentrated (1.84) acid at 32 deg. fahr. followed by redistillation. The color of the product did not deepen after the sample had been exposed to the light (sunlight part of the time) for approximately 30 days.

Other most interesting results have been secured but it is not advisable to discuss them at this time until further experiment and verification.

[18] Where steam is used with the oil vapors, it is claimed that this condition does not obtain and that a sweeter product is obtained.

[19] See Ellis and Wells, Jour. Ind. Eng. Chem. 7 (1915), 1029.

[20] Brooks and Humphrey, Jour. Am. Chem. Soc. 40 (1918), 822.

A Census of Special Libraries

Because of the fact that there does not exist an adequate directory of special libraries, the Special Libraries Association is now actively engaged in determining the number of such institutions throughout the country. During the war, when army camps and military centers were being furnished with libraries for research and educational work, the lack of a satisfactory list of information centers was keenly felt. There were a large number of occasions when army men could have used a directory of institutions or corporations having special libraries if such a publication had been in existence. It is to fill such a want that the present census is being taken.

A special library has been defined as a good working collection of information upon a specific subject or field of activity; it may consist of general or even limited material serving the interests of a special clientele, and preferably be in charge of a specialist trained in the use and application of the particular material. Libraries coming within the above qualifications are earnestly requested by the Special Libraries Association to supply the following information:

1 Name of institution or company
2 Name by which library is known
3 Name of librarian or custodian
4 Can it be classified as any of the following: financial; business; legal; engineering or technical; institutional; municipal; reference; agricultural?
5 Does it serve a special clientele?
6 Would your librarian be willing to assist other special libraries to a reasonable extent?

These data should be sent to the Chairman, Library Census Committee, care of General Electric Company, Schenectady, N. Y.